LAKE MERCED WATER RESOURCE PLANNING STUDY
San Francisco Water Department

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May 24, 1993

Mr. Mickey Heo
SAN FRANCISCO WATER DEPARTMENT
425 Mason Street
San Francisco, California

RE: SUBMITTAL OF THE LAKE MERCED
WATER RESOURCE PLANNING STUDY

Dear Mr. Heo,

In accordance with our contract with the San Francisco Water Department, Geo/Resource Consultants, Inc. (GRC) is pleased to transmit the Lake Merced Water Resource Planning Study report.

As an evaluation of new and existing data pertinent to lake use and water quality issues, this report will serve as a key step in the planning process for Lake Merced. Thank you for the opportunity to work on this interesting study.

Sincerely,

GEO/RESOURCE CONSULTANTS, INC.

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LAKE MERCED WATER RESOURCE PLANNING STUDY

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EXECUTIVE SUMMARY

Lake Merced has served a number of functions for the City of San Francisco. In the late 1800s, it was a source of municipal water supply. When lake water was replaced by other water sources in 1910, its primary use was relegated to emergency water supply, and has also been used as source of irrigation water up till the present. In 1950, the management of the lake and surrounding lands was granted to the San Francisco Recreation and Park Department (SFRPD) by the San Francisco Public Utilities Commission (PUC) with certain restrictions. However, the ultimate responsibility for the lake rests with the San Francisco Water Department (SFWD). Beneficial uses of the lake have been identified by the California Regional Water Quality Control Board (RWQCB) as a potential municipal supply, a recreational facility, and a habitat for various fish and wildlife species.

Since the mid-1900s, lake levels and lake quality have slowly declined, impacting established beneficial uses of the lake. Historic lake levels are shown in Figures 1-1 and 1-2. Lake level measurements made at the lake are referenced to a gauge board located near the Lake Merced Pump Station. Gauge board measurements are 8.76 feet higher than mean sea level (MSL) and 17.50 feet higher than City Datum. In this study, all lake measurements referenced are relative to the gauge board, unless otherwise indicated. The lowest lake level recorded was approximately 15.5 feet in 1990. In August, 1992, the lake was measured at 17.67 feet.

The Lake Merced Water Resource Planning Study demonstrates that the primary beneficial uses of the lake, emergency water supply, recreation, and as a fish and wildlife habitat, are, for the most part, not in conflict with each other. Additionally, most beneficial uses would be enhanced by higher water levels and improved water quality. This study concludes that a lake level of 26 feet (relative to the gauge board) would generally satisfy most beneficial uses, and could improve some water quality characteristics. Other recommended mitigations to improve lake quality include installation of additional restroom facilities, increased monitoring, and potentially, removal of lead shot at the Pacific Rod and Gun Club, and increased monitoring and management of fertilizer and pesticide application.

This study concludes that the use of the lake as a source of emergency water supply should be its first management priority. Following that, lake management priorities should be protection of special-status species of fish and wildlife, recreational uses, and as a habitat for a wide variety of fish and wildlife.

Historic lake level decline is attributed to increased urbanization, nearby pumping, and drought. Resource alternatives to raise lake levels include the addition of outside sources of water, the addition of groundwater from local wells, the addition of stormwater, the replacement of groundwater pumped for irrigation by reclaimed water, and the implementation of an injection mound adjacent to the lake.

This study represents a first step in the formation of a Lake Merced Water Management Plan. Future work should focus on formalizing lake level and water quality criteria and developing and evaluating resource alternatives to ultimately improve lake quality.

Description and Uses of Lake Merced

Lake Merced is an exposure of the surrounding groundwater aquifer. Historically, Lake Merced was a single lake with direct connection to the ocean. Over time, Lake Merced has been artificially separated from the ocean and into three separate lakes known as North Lake, South Lake, and Impound Lake.

The water quality of the lake is governed by its physical configuration as a surface impoundment, by inflowing groundwater, by recreational uses, and resident fish and wildlife, and to a small extent, by stormwater discharge. As a shallow surface water body, the formation of algae is very common and related to naturally occurring physical processes. Otherwise lake quality is generally good.

Recreational use at Lake Merced, and its use by a wide variety of fish and wildlife, is considerable and may contribute to the high total coliform content measured in lake samples. Additionally, although management practices related to pesticide and fertilizer applications appear to be good at Harding Park Municipal Golf Course (HPMGC), it is not known whether these compounds are contributing nitrate and/or pesticides to the lake. Previous studies indicate that nearby shooting from the Pacific Rod and Gun Club has contributed to the high lead concentrations measured in some soil and sediment samples. Although lead shot would not tend to be soluble under the chemical conditions characteristic of the lake, it could be toxic to diving ducks if ingested.

Stormwater enters the lake at some areas around the lake perimeter and from overflow from the Vista Grande runoff culvert maintained by Daly City. Available water quality testing for San Francisco stormwater suggests that contaminants reaching the lake could include metals and petroleum constituents. Water quality testing for two samples of Vista Grande runoff collected in 1984 indicated that Vista Grande runoff is higher than Lake Merced water in total coliform, turbidity, and suspended solids, copper and zinc, but lower in conductivity and hardness. Sampling conducted in January and February, 1993, indicate similar trends.

Estimates of stormwater contribution to the lake indicate that stormwater contributes very little water to the lake overall, ranging from 1 to 6 percent, except during 5-year floods and greater at the shallow Impound Lake. At those times, the stormwater overflow volume from Vista Grande is estimated to 241 percent of the capacity of Impound Lake. Therefore, with the exception of potential flooding at Impound Lake, stormwater probably contributes very little to the water quality conditions of Lake Merced.

Regulatory impacts of lake management include the EPA National Pollution Discharge Elimination System (NPDES) permitting requirements, and the Surface Water Treatment Rule. NPDES permitting will result in increased management of stormwater quality, with the goal of improving discharge quality. The Surface Water Treatment Rule stipulates the use of filtration as a required treatment for surface waters intended for potable use. As implementation of the Surface Water Treatment Rule would have significant economic impact on the City of San Francisco, Lake Merced is likely to remain as a source of non-potable water and/or emergency water.

Beneficial Use Requirements

Lake beneficial uses designated in the RWQCB 1986 "Basin Plan" include municipal supply (potential), recreation, and fish and wildlife habitat. Currently, the lake is considered by the SFWD as a source of emergency water supply, as well as a recreational facility and fish and wildlife habitat. Lake Merced can be used as an emergency water supply by pumping water directly from the lake at the Lake Merced Pump Station. These pumps can distribute water to the SFWD's Sunset Reservoir (33.33 million gallons per day; mgd) and to the Sutro Reservoir (16.66 mgd). The minimum pumping level at Lake Merced is controlled by the elevation of the two lower intake drums. Elevation 9 feet is considered to be the lowest lake level required to provide emergency water supply.

Emergency water from Lake Merced would be used primarily as a source of firefighting water, although during distribution it could potentially mix with the City's drinking water supply. "Alternate water sources" to be used during an emergency are allowable by the California Department of Health Services (DOHS) if their distribution is accompanied by a Boil Water Order (BWO) or Unsafe Water Alert (UWA). In the event that Lake Merced water would be needed during an emergency, the SFWD plans to issue either a BWO or UWA and to disinfect Lake Merced water with sodium hypochlorite in order to attain bacteriological water quality standards.

Recreational uses at Lake Merced primarily include fishing and boating, although other uses such as jogging, picnicking, bicycling, and bird watching also occur. Wind-surfing, considered a "light body" contact recreational activity, is allowed on South Lake only. Other recreational uses related to aesthetic enjoyment, such as golfing and shooting, also occur on surrounding lands. Water level criteria for fishing, boating, and general aesthetics has been identified in this study to be 26 feet. However, recreational uses such as bird watching may benefit from lower lake levels.

Water quality criteria for recreational uses are set forth in the RWQCB Basin Plan and in subsequent proposed amendments. The Basin Plan sets forth general objectives for color, tastes, odors, floating material, suspended material, sediment, biostimulatory substances, salinity and oil and grease. More specific objectives are recommended for pH, dissolved oxygen, coliform bacteria, temperature, toxicity, un-ionized ammonia, and sulfide. Basin Plan water quality criteria that are not met for contact and non-contact recreational sports at Lake Merced are judged in this study to include color, taste, odor, floating material, sediment, turbidity, and possibly, fecal coliform.

Fish and wildlife species are extensive at Lake Merced, including a variety of fish, vegetation, birds, amphibians, mammals and reptiles. Trout are stocked by the California Department of Fish and Game (DFG), and warmwater fish are also present. Sixteen special-status wildlife species are known to occur or have potential to occur at Lake Merced. The state-threatened bank swallow nest at Fort Funston and Lake Merced's marsh habitat provide a critical food source. The saltmarsh yellowthroat, which nest along the banks of North Lake, is a candidate species for federal listing as threatened or endangered. Other special-status or endangered species have also been observed to occur at Lake Merced.

Water level criteria range widely for the identified fish and wildlife. The best lake level conditions for trout would be high, which result in colder water temperatures and higher dissolved oxygen contents. Although high water levels may reduce spawning habitat for warmwater fish and the amount of marsh habitat, this study has determined that even at higher lake levels, conditions for warmwater fish and marsh habitat would remain "fair." Although recent water levels have been low, they have been sufficient to support fish populations in South and North lakes. In September, 1992, however, water levels were so low in Impound Lake, that the fish population was threatened and water was pumped into Impound Lake from South Lake.

Water quality criteria for various fish species at Lake Merced are similar, as both trout and warmwater fish require higher dissolved oxygen contents than what has sometimes been measured at the lake. Otherwise, lake quality is adequate for the fish and wildlife species identified at the lake. Predation of fish by pisciverous birds is potentially reduced by the turbid lake quality, and it is judged that higher lake levels would not necessarily reduce predation.

The RWQCB lists Lake Merced as a potential municipal water supply. At present, Lake Merced could not be used as a potable water source because it does not meet primary drinking water standards for total coliform and turbidity. If the lake were to be considered for potable use, these standards must be met in accordance with DOHS standards and domestic water supply monitoring should be implemented. Additionally, water-contact recreational sports must be prohibited.

The most likely potential future beneficial use of Lake Merced that is consistent with existing beneficial uses is as a location of artificial groundwater recharge. Artificially raising lake levels will also result in recharge of surrounding groundwater resources—and, in fact, could be viewed as an independent beneficial use of the lake in the future.

Impacts of Beneficial Uses on Each Other

Water level criteria for beneficial uses identified in this study are depicted on Figure 3-8. This figure may be used to visually evaluate potential impacts of specific beneficial use water level criteria on other beneficial uses.

Management of the lake for emergency water use implies maintaining lake levels at its highest capacity (approximately 30 feet). However, most recreational uses would benefit from a maximum lake level of 26 feet. Maintaining the lake level to 26 feet is not anticipated to have a great effect on potential emergency water supply because inflow to the lake is substantial and the estimated water quantity available is relatively high (50 mgd for at least 3 months). Other recreational uses, including bird watching, would be impacted by raising lake levels above current levels, but these activities could still continue in a somewhat lesser capacity.

Higher lake levels for emergency water use would enhance conditions for trout and diving birds and probably would not substantially affect marsh habitat or warmwater fish. Higher lake levels would result in greater fish populations overall, although trout populations would probably benefit more than warmwater fish. The rate at which the lake level is raised should be slow enough to allow tules and willows to reestablish upslope. Upland trees and shrubs that have recently established themselves close to the shore would probably die off as lake levels rise.

Turbidity levels could be improved by copper sulfate treatment just prior to emergency water supply distribution. Copper sulfate treatment to meet rare emergency supply demands is not anticipated to significantly impact fish and wildlife. However, approval for its use prior to distribution should be obtained from the DFG.

Lake level decline from emergency water use is estimated at about 2 inches per day. This rate of lake level decline is not expected to cause significant impacts to wildlife species or their habitats. However, there may be significant loss of tule vegetation if a decline of more than 3 feet persisted for more than several weeks.

Managing the lake for recreational uses may lower water quality overall. It is inevitable that heavy use around the lake would increase bacteria levels somewhat, as well as the amount of floating material and associated off-colors and odors. However, existing recreational controls exerted by the PUC Resolution probably serves to limit these impacts somewhat.

Although turf management at the HPMGC appears acceptable, it is currently not known whether fertilizers or pesticides impact lake quality. Impacts from shooting at the Pacific Gun and Rod Club on lake water quality in terms of drinking water standards is not expected as existing lake conditions do not encourage the dissolution of lead. Impacts of lead on aquatic biota are not known.

Managing the lake for most recreational uses is not expected to substan-tially impact fish and wildlife. Desired lake level criteria is generally higher than current levels for most uses, thus enhancing fish populations overall. Most water quality impacts from recreation do not impact fish and wildlife, with the exception of potential ingestion of lead shot by diving ducks.

Impacts of Stormwater Inflow on Beneficial Uses

Impacts of current stormwater runoff on potential emergency supply are judged to be relatively minimal due to low volumes of inflow estimated relative to the volume of South and North lakes. Additionally, any increases in total coliform content from stormwater would be treated using disinfection prior to distribution for emergency water supply.

Because of the relatively small capacity of Impound Lake, impacts of current stormwater runoff from Vista Grande into Impound Lake may be significant if lake levels are low. It is anticipated that some Basin Plan objectives for recreation, such as fecal coliform, suspended materials, and turbidity could be significantly exceeded during 5-year storms and greater at Impound Lake. A settling system, as proposed by Daly City, in conjunction with a new overflow diversion structure, could decrease these contaminants.

Impacts of current stormwater runoff on fish and wildlife may be evaluated from toxicity tests conducted using rainbow trout containing various proportions of Vista Grande stormwater runoff. None of the fish experienced deleterious effects, even the trout placed in un-diluted stormwater. However, these results are not adequate to rule out the possibility of chronic toxicity or bioaccumulation associated with metals, pesticides or other trance organic compounds. Impacts due to lake level rise during storms is not expected to impact nesting birds or marsh habitat significantly.

A water quality testing program for testing both Vista Grande stormwater and Lake Merced water was designed by SFWD in January, 1993 in order to evaluate potential impacts of stormwater on lake quality. Currently, the Daly City Department of Water and Wastewater Resources (DCDWWR) is conducting this program for the Vista Grande stormwater runoff. The constituents to be tested include extractable organics (acids and base neutrals), priority metals, oil and grease, pH, total suspended solids, conductivity, total organic carbon (TOC) and turbidity. Bacteria (fecal and total coliform) and nitrogen should be added to this suite.

Recommended Preliminary Lake Level and Quality Criteria, Monitoring Program and Mitigations

A preliminary lake level to satisfy most lake uses is suggested at 26 feet (approximately 8 feet higher than the August, 1992 level of 17.67 feet, and 5 feet higher than the long-term lake level predicted at 21 feet). This lake level would be ideal for most recreational uses, should not substantially effect wetland habitat and associated wildlife, would improve conditions for trout, and could lessen algae somewhat by increasing the lake volume.

Additionally, the amount of emergency water supply would be increased.

The quality of the lake appears to be generally acceptable as an emergency water supply. The quality of the lake as either a water-contact or non-contact water recreational facility does not currently meet some RWQCB Basin Plan standards for inland surface water bodies. The lake quality should be improved to meet these regulatory criteria.

The SFWD currently monitors North and South Lakes monthly for basic water chemistry and annually for a variety of organic and non-organic constituents. After analyzing lake beneficial uses, this study concludes that most of the parameters of concern are being monitored; however, additional parameters, including chlorophyll-A, temperature, odor, fecal coliform, pesticides and oil and grease should be added to the monitoring suite. Nitrates should be monitored in shallow wells that could be installed along the shoreline of HPMGC in order to assess potential impacts of fertilizers.

In order to achieve the lake level and quality criteria above, the following mitigations are recommended:

- Increase lake levels slowly to approximately 26 feet using a source of water of appropriate water quality;
- Increase the number of restroom facilities to potentially reduce coliform bacteria levels;
- Implement disinfection treatment just prior to distribution of lake water for emergency supply;
- Re-stock fish populations and re-establish tules in the event that Lake Merced lake levels are significantly lowered by use for emergency water supply;
- Implement various management practices at the HPGMC to reduce potential impacts of fertilizers and pesticides on lake quality;
- Modify existing monitoring program to include chloropyll-A, temperature, taste and odor compounds, fecal coliform, pesticides, TOC, and oil and grease. Nitrate should be monitored in shallow wells at HPMGC;
- Collect lake water samples in the vicinity of the Pacific Rod and Gun Club and analyze for lead using a laboratory detection limit of 1 ug/l to evaluate potential effects on aquatic biota.

Other mitigations not specifically related to the improvement of lake water quality would include:

- Review the March, 1993 study on lead characterization at the Pacific Rod and Gun Club; consider plans to 1) monitor plants, invertebrates and waterfowl for lead; 2) reduce lead concentrations by dredging; 3) discontinue use of lead shot;
- Water quality data, specifically, total coliform levels in South Lake, should be reviewed by the San Francisco Department of Public Health (SFDPH), in conjunction with other City agencies, in order to develop a policy regarding use of the lake for water-contact sports.
- Create an Emergency Operations Plan that describes implementation of Lake Merced water for emergency water supply.

Beneficial Use Priorities and Potential Conflicts

Due to the relative absence of other emergency water supply sources currently on line in the western part of San Francisco, the use of Lake Merced as a source of emergency water supply is recommended as the first priority of management of the lake.

The second most important management strategy for Lake Merced should be to meet applicable laws that protect threatened and special status plant and animal species. At Lake Merced, only the bank swallow is listed as threatened and because the lake serves only as a food source for the swallows, management of the lake is unlikely to cause mortality unless the lake is allowed to go dry. Special status species are protected indirectly by California Environmental Quality Act (CEQA). The special status species at Lake Merced are generally related to the tule and marsh habitat and this study has determined that the condition of these species will remain "fair," even at higher lake levels.

The third priority management strategy for Lake Merced should be the management of the lake for recreational uses. Lake Merced is well known throughout the Bay Area as a recreational center providing a wide variety of uses including fishing, boating, picnicking, windsurfing, and golfing. Additionally, the PUC Resolution asserts that the lake can both be used for recreational purposes as well as for a water supply, with certain restrictions.

Lake Merced is currently a habitat for a large variety of fish and wildlife. Therefore, the fourth priority for Lake Merced should be to manage the lake to provide suitable habitat for non-special status fish and wildlife.

Some conflicts occur between beneficial uses and RWQCB water quality criteria; however, relatively minimal conflicts occur between the various beneficial uses themselves. Conflicts identified include:

- Recreation and fish and wildlife beneficial uses and a variety of RWQCB water quality standards for inland surface water bodies;
- Emergency water supply, fishing and boating, and "high water" fish and wildlife habitats with optimum conditions for tule/marsh and warmwater fish habitat; although it appears that acceptable conditions could still be maintained at high water levels.

Based on the prioritization of beneficial uses presented above, management objectives for the lake should be as follows:

1) Emergency water supply;
2) Non-contact recreation;
3) Fish and wildlife habitats (emphasis on "high water" fish and wildlife habitats, while maintaining acceptable conditions for "low water" fish and wildlife habitats.

A public meeting was held on April 26, 1993 to invite comments from the public regarding the condition and future uses of Lake Merced. This meeting identified several additional conflicts that should be addressed prior to formulation of a final lake management plan.

Hydrology of Lake Merced

A groundwater model of the Lake Merced-Daly City area was developed for this study to answer questions specifically related to Lake Merced hydrology. The model was used to estimate groundwater budgets and the effects of well pumping and drought on lake levels. Three years, 1983, 1985, and 1990 were selected to represent wet, normal, and dry conditions, respectively. The model was manipulated to explore the effects of pumping at nearby golf courses, from Daly City municipal wells, and from the recent drought.

The historical effect on lake levels from pumping wells located at Harding Park, San Francisco Golf Club, Olympic Golf Club, and Lake Merced County Club golf courses was estimated by using the model to simulate the 1949-1990 period without pumpage from those wells. The resulting simulated water levels were consistently 4 to 5 feet higher than historical lake levels.

The historical effect on lake levels from municipal wells in Daly City was estimated by using the model to simulate the 1949-1990 period without pumpage from those wells. The results of the simulation indicate that without Daly City pumpage, lake levels would have been approximately 10 feet higher than historical lake levels.

Between 1986 and 1990, annual rainfall averaged approximately 12.6 inches (61 percent of normal), and lake levels declined approximately 8 feet as a result.

The amount of emergency water available from Lake Merced includes the amount of water in the lake plus the amount of groundwater that would flow into the lake when lake levels are drawn down by pumping. The magnitude of this inflow was estimated by simulating emergency pumping at a rate of 50 mgd for a period of 84 days. The results of the simulation indicated that the lake level declined approximately 7 feet over the 84-day period.

Lake Resource Alternatives

Several potential water resource strategies were evaluated using the groundwater flow model described above. Each alternative represents a single type of action and is implemented to the extent necessary to increase the long-term average water level in Lake Merced to 26 feet.

The lake resource alternatives include the addition of water from an outside source (i.e. Hetch Hetchy or groundwater), from nearby groundwater wells, from increased stormwater inflow, from replacement of groundwater pumped from nearby wells from irrigation with reclaimed water, and from a potential, nearby reclaimed water injection mound designed to reduce groundwater outflow to the ocean. Most of the individual alternatives were able to achieve the target lake level. None of the alternatives are mutually exclusive, so the target level could also be achieved by using a combination of strategies implemented to varying extents.

Water quality impacts from the various water resource alternatives presented are wide-ranging. Use of Hetch Hetchy water would generally improve water quality although de-chlorination would be required. Adding groundwater to Lake Merced would not significantly impact water quality since the lake is currently sustained by groundwater inflow.

Potential water quality impacts of adding overflow from Vista Grande Tunnel to Lake Merced could include an increase in total coliform, turbidity and suspended solids. Although metal concentrations are slightly higher in stormwater than lake water, preliminary calculations suggest that resultant metal concentrations in lake water would be below Drinking Water Standards. To reduce contaminant levels going into the lake, the DCDWWR proposes to construct a settling system through which stormwater would be diverted.

Reclaimed water that could be used to replace irrigation water at nearby golf courses should not significantly impact lake quality if irrigation practices are carefully controlled. Reclaimed water used as a groundwater recharge mound would not be expected to impact lake quality unless the lake were pumped for emergency supply, thereby potentially resulting in reclaimed water inflow into the lake. Estimated future reclaimed water quality indicate that increases in conductivity, chlorides, sodium, nitrogen, copper, and zinc could occur at the lake.

Lake Merced Water Management Strategy

The work performed in the current study represents only a portion of the work required to ultimately develop a Lake Merced Water Management Plan. The remaining work is listed below:

- Form a Lake Merced Management Committee;
- Resolve Remaining Beneficial User Conflicts and finalize lake level and water quality criteria;
- Develop and Evaluate Water Resource Alternatives;
- Obtain Input to Alternatives Development;
- Recommend a Preferred Lake Merced Water Management Plan;
- Conduct an Environmental Impact Review;
- Adopt Plan and Implement.

A Lake Management Committee (LMC) should be created consisting of representatives from the SFRPD, SFWD, SFDPW, SFDPH, RWQCB, DCDWWR and the Office of Environmental Review (OER) and the Office of the City Attorney (OCA), Water Section.

The LMC should resolve remaining beneficial user conflicts identified in the public meeting held April 26, 1993 and should finalize lake level and water quality criteria that is presented in this report. The monitoring program recommended by this study should be implemented, and the development and evaluation process of the preliminary water resource alternatives presented by the study should ensue. Two outstanding issues related to the design of a system to introduce supplemental water to the lake include the rate at which water should be introduced into the lake, and the potential restoration of a spillway to control lake levels during wet years.

It will be important to obtain input during the formulation of alternatives to make them responsive to the needs of beneficial users and to assure that the preferred alternative is acceptable within a regional framework. Input should be obtained from Lake Merced interest groups and the general public, governmental agencies not included in the LMC, and the steering committee for the formation of a San Francisco Groundwater Management Plan.

The water resource alternative selected would be developed into a Lake Water Management Plan to be integrated into an overall Lake Merced Management Plan which would address other park issues unrelated to water resource issues. The Plan would undergo environmental review, and upon approval, would be adopted by the PUC and implemented accordingly.

Section 1

INTRODUCTION

Lake Merced has historically served a number of functions for the City of San Francisco. In the late 1800s, it was an important source of municipal water supply, and, although it has not been used as such since the early 1900s, it still remains as a potential source of water for San Francisco. In 1950, the management of the lake and surrounding lands was granted to the SFRPD by the PUC, although ultimate responsibility as a source of water supply still remains with the SFWD.

Since about the mid 1900s, lake levels and lake quality have slowly declined, impacting potential water resource capabilities, as well as established recreational uses, and as a habitat for fish, wildlife and vegetation. Historic water level measurements are shown in Figures 1-1 and 1-2. Lake level decline has been attributed to pumping from the lake, pumping from the encompassing groundwater system, increased urbanization, and drought.

1.1 PURPOSE AND SCOPE OF STUDY

The SFWD, along with other governmental agencies, wishes to improve lake quality in such a manner that all established beneficial uses of the lake are served. To accomplish this goal, a Lake Merced Task Force was established to study the water quality problems at Lake Merced. This Task Force obtained State funds for a water quality study that would identify current and potential future uses of the lake; define the relationship between nearby groundwater usage, lake storage, water quality, and existing beneficial uses; set criteria from which to rank and evaluate competing beneficial uses, recommend alternative means of maintaining water quality protection and recommend a lake management strategy program. The present study was initiated to fulfill these goals.

Throughout the study, a Lake Merced Steering Committee, formed from the Lake Merced Task Force, provided guidance to the Contractor. The Lake Merced Steering Committee consisted of the SFWD (Water Quality, Resources and Planning, and Distribution divisions), the SFRPD, the SFDPH, the San Francisco Department of Public Works - Clean Water Program (SFDPW), the DCDWWR, the RWQCB, and the Office of the City Attorney (OCA).

addition, of concern are significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH as a result of climatological or other conditions. So, for example, raw water with total coliform greater than 5,000 MPN/100 ml, and color between 40 and 75 Color Units (CU), will require complete treatment. Direct filtration (without sedimentation) should only be considered where total coliform is less than 500 MPN/100 ml; turbidities between 7 and 14 NTU; and color between 10 and 40 CU. The regulations require compliance by June 29, 1993. Exemptions are specified, but are severely limited in California.

Because of high total coliform, color and turbidity levels, the Surface Water Treatment Rule virtually removes Lake Merced as a municipal potable water supply with only the existing disinfection facility. Therefore, the SFWD has informally adopted the policy that Lake Merced would serve only as an emergency water source, accompanied by a BWO or UWA, in order to avoid its direct use as drinking water.

Section 2

DESCRIPTION AND USES OF LAKE MERCED

This Section describes the formation of Lake Merced, its usage as a municipal and irrigation water supply over the years, and the factors that define it's water quality characteristics. Additionally, the potential impact of recent regulatory rules, the Surface Water Treatment Rule and the NPDES on the usage and quality of Lake Merced is discussed.

2.1 LAKE DEVELOPMENT AND HISTORICAL USAGE

Lake Merced is known to be an exposure of the surrounding groundwater aquifer, commonly known as the Westside Groundwater Basin. The hydrology of the lake, including a qualitative assessment of lake recharge and discharge has been previously described by the U.S. Geological Survey (USGS) in a Water Resource publication (Yates, 1990).

Historically, Lake Merced was a single lake with a direct connection to the Pacific Ocean. Lake Merced has been separated from the ocean by a sand spit during most of the last two centuries. During an earthquake in 1852 the spit was breached, forming a channel in the vicinity of Sloat Boulevard (See Figure 2-1). The channel was subsequently filled by longshore transport processes and human intervention.

By 1880, the lake was again isolated from the ocean, and berms were constructed separating the lake into three separate lakes, North Lake, South Lake, and Impound Lake. North Lake is divided into eastern (Northeast Lake) and western (Northwest Lake) parts by a narrow channel between the two lakes. Although waters of North Lake and South Lake represent an exposure of groundwater, and are in relative equilibrium with each other, flow from one lake to the other is impeded by a strip of land between the two lakes. The bottom of North Lake is at a higher elevation than South Lake. In order to prevent overflow from North Lake in times of high water levels, an underwater gate was constructed between the two lakes. Additionally, a pump was installed to enhance flow from North Lake into South Lake in this event. This gate has not been used for some time as lake levels have been low, and is kept open on a permanent basis (Personal communication, Mr. Frank Bezak).

Impound Lake is separated from South Lake by a berm and bridge. Throughflow can occur through a causeway existing between the top of the berm and bottom of the bridge.

The Spring Valley Water District developed Lake Merced as a potable water supply for San Francisco in the 1870s. The company pumped an average of 2.94 mgd between 1877 and 1912, originally from the North Lake. In 1891, the lake's importance as a municipal water supply was enhanced by installing a new pump station on the South Lake with a 7.5 mgd capacity (Personal communication, Mr. Josh Milstein).

After about 1910, Spring Valley developed other supplies in the Livermore Valley and on Alameda Creek and the company ceased pumping water from Lake Merced for domestic use due to poor water quality. During this period, Lake Merced began to be viewed as an emergency water supply by Spring Valley, largely due to water quality concerns caused by increasing development in the lake watershed. However, irrigation usage of lake water continued by Spring Valley tenants. From 1916 to 1930, Spring Valley sold large parcels of its watershed holdings to golf/country clubs including the Olympic Club, the San Francisco Golf Club, and the Lake Merced Golf and Country Club (Personal communication, Mr. Josh Milstein). Currently, the lakes are surrounded by highways, urban and residential development, and two golf courses (See Figure 2-2). Consumptive use of lake water for irrigation has continued by the HPMGC and Pacific Rod and Gun Club up to a few years ago and was discontinued due to low lake levels. The lake has been considered an important source of emergency water for firefighting since the early 1900s (Spring Valley Water District, C.E. Grunsky, 1915, letter from Mr. Josh Milstein to Ms. Eva Vanek, December 14, 1992).

The City of San Francisco purchased the last remaining parcel (the Lake Merced Tract, consisting of the lake and immediately surrounding perimeter lands) from Spring Valley in 1930. The SFWD managed the lake as an emergency water supply until 1950 when the PUC Resolution 10,435 ceded jurisdiction of the surface of the lake and perimeter lands to the SFRPD to develop beneficial recreational uses at the lake while still maintaining its status as an emergency water supply (See Appendix A).

The PUC Resolution sets forth specific conditions for the use of Lake Merced. Conditions No. 1 and 2 state the following:

1. *"The Park and Recreation Commission agrees that the primary purpose of the Lake Merced Tract is to supply potable water to the water consumers in San Francisco and that they will do nothing or suffer or permit anything to be done that, in the opinion of the Public Utilities Commission, is detrimental to the quality or use of the water in Lake Merced."*

2. *"The water drawn from the lake for all purposes shall be not more than the average yield of the lake and in no instance shall the water level be drawn down below 27 feet on the gauge."*

It should be noted that the water level criteria specified in the PUC Resolution, 27 feet, has not been maintained since some time between 1955 and 1960 (See Figure 1-2).

3. *"In view of the fact that the lake may be used as the domestic water supply for the City, no swimming shall be permitted, no gasoline driven motorboats shall be permitted to operate regularly on the lake, all sewage shall be removed from the lake area, and nothing shall be done that would tend to make the waters of the lake unfit for human consumption."*

2.2 LAKE MERCED WATER QUALITY DETERMINANTS

The water quality of the lake is governed by its physical configuration: 1) as a shallow surface impoundment, 2) by the water quality of inflowing groundwater, 3) by impacts imposed by recreational uses and resident fish and wildlife, and 4) to a small extent, by stormwater discharge.

2.2.1 Impoundment Characteristics

Lake Merced water quality is governed in part, by characteristics common to many shallow surface water bodies. In particular, the formation of algae in Lake Merced is common of many lakes. Algae was reported as early as 1912 (Freeman Report), suggesting that its presence may be due, at least in part, to inherent characteristics of the lake. The development and extent of algae formation are influenced by a variety of physical, chemical, and biological factors such as lake depth relative to surface area, available light, pH, temperature, and nutrients. Phosphorus, nitrogen, and silicon are the key nutrients, with iron, manganese, sulphur, zinc, copper, cobalt, and molybdenum also essential for algal growth.

The primary physical factors governing algae formation include: lake depth, ratio of water volume to surface area, detention time, temperature, light penetration, and attachment sites. Deeper lakes are generally less productive for algae than shallower ones because they have a greater volume of nutrient inflow and have less surface area in which algae can live. Droughts would increase algae productivity due to a decrease in lake volume. Lake Merced fits the description of a higher - algae producer since it is a relatively shallow water body. The recent drought period and consequent low lake levels appear to have increased algae content.

The main quality impacts of extensive algae blooms are odor, turbidity, TOC, and color. Algae blooms can impart unpleasant tastes and odors to the water and to fish caught by anglers; they then can cause fishkill during decomposition due to the higher TOC and related oxygen depletion (which occurred in September, 1992 at Impound Lake); they would complicate the disinfection process due to potential formation of trihalomethanes (THMs), and they clog filters, which is of particular concern in the event that the lake water is distributed through the San Francisco water supply system.

2.2.2 Groundwater

As would be expected, Lake Merced's water quality is similar to that of the surrounding aquifer. A review of Lake Merced water quality characteristics (Table 2-1), and water quality analyses of wells in the immediate vicinity of the lake, showed similar alkalinity, chlorides, hardness, and conductivity between the lake and nearby groundwater wells (Yates, 1990). In general, the water in Lake Merced is hard, with high alkalinity and total dissolved solids (TDS) content (as indicated by high conductivity). In comparison, rain, runoff, and Hetch Hetchy water are soft, with very low alkalinity and TDS.

Because groundwater is the largest source of recharge to Lake Merced, its nutrient content (total nitrogen plus phosphorus) probably contributes substantially to the growth of algae and phytoplankton in the lake. In 1987 and 1988, the USGS conducted well water sampling at the San Francisco Golf Club and San Francisco State University, both upgradient of the lake. Chemical results indicated dissolved nitrogen (as N) ranged from 7.6 to 12 mg/l. At an annual groundwater inflow rate of about 800 acre-feet per year (Yates, 1990), and an assumed average total nitrogen concentration of 11 mg/l, 23,900 pounds of nitrogen per year could enter the lake, or about 88 pounds per acre. This loading rate is of the same order of magnitude as nitrogen applications for many agricultural crops.

Almost all nitrogen entering Lake Merced is taken up by plants, algae, and phytoplankton. The nitrate concentration in the lake averaged 0.1 mg/l in 1988 (Yates, 1990). The fact that essentially all of the nitrogen is consumed by plants, algae and phytoplankton indicates that it is the limiting factor for those organisms. If other factors were limiting, such as phosphorus or sunlight, higher residual nitrogen concentrations would be expected. This means that the population or biomass of these organisms is a function of the nitrogen mass loading rate.

The nitrogen mass loading rate could be decreased by decreasing the rate of inflow of groundwater or by decreasing the concentration of nitrogen in the groundwater. A nitrogen isotope study for Golden Gate Park and Lake Merced indicated that the relatively high nitrogen concentrations measured in wells within western San Francisco is derived approximately equally from inorganic fertilizers and leaky sewer pipes (Yates, 1990). Nitrogen influx from these sources would be fairly constant and independent of lake level.

Temporary inflows to Lake Merced have come from construction groundwater dewatering for the construction of the Oceanside Water Pollution Control Plant (OWPCP) and the Lake Merced Transport Tunnel. Oceanside dewatering flows were introduced into Lake Merced for a period in 1990, but were discontinued as chloride concentrations increased.

Groundwater dewatering for the construction of the Lake Merced Transport tunnel under Skyline Boulevard and John Muir Drive has introduced temporary flows into the road storm drains along Skyline Boulevard and John Muir Drive, which then entered the lake. Quantities and qualities of these dewatering discharges into the lake have been tracked (See Appendix B). For most of May and June, 1992, flows approaching 5.5 mgd were introduced into South Lake. The groundwater had a lower pH and higher chloride, conductivity, alkalinity, and hardness when compared to typical South Lake quality.

In addition, turbidity and total coliform counts were significantly higher than the lake and could have also contributed nitrate to lake water. This was attributed to localized disruption of sewage lines during the course of construction (Personal communication, Ms. Denise Rousseau). Thus it is known, at least at this one time, that sewer leakage has occurred in the vicinity of Lake Merced, thereby impacting lake quality.

In January 13, 1992, a sample collected from a boring located near the Lake Merced Pump Station was submitted for a wide variety of organics (including pesticides) and inorganics (See Appendix C). Sample constituents showed compliance of mineral and organic chemicals with drinking water standards with the exception of iron, manganese, and total coliform.

2.2.3 Recreational Use and Fish and Wildlife Habitat

Non-contact recreational use is focused on fishing, pleasure boating, golfing, and walking, jogging and bicycling along the asphalt perimeter path. Water-contact sports allowed at Lake Merced include windsurfing and boating for sport fishing. Sanitary controls include trash cans which are provided around the lake in areas where recreation use is highest: at the golf course, along the beaches, near parking lots, near fishing piers and in picnicking areas. Two people are employed by the SFRPD to pick up trash at Lake Merced. However, trash is a major problem at Lake Merced due to the urban setting of the lake, the heavy use it receives, and reduced maintenance budgets (Personal communication, Mr. Bob Killian).

Two public restroom facilities are located at Lake Merced: the Harding Park Clubhouse and the Pacific Rod and Gun Club, which is only open Wednesday, Saturday and Sunday. Several portable outhouses are located around the Harding and Fleming golf courses. The rest of the park does not maintain any restroom facilities. Heavy recreational use is likely to contribute to coliform bacteria, turbidity, and floating material.

Seagulls and other birds are common on and above the surface of Lake Merced, and they probably impact the coliform bacteria level in the lake water considerably. No specific data quantifying their impact is available.

GOLF COURSE MAINTENANCE

The 150 acres of land dedicated to the HPMGC, located between North and South Lakes, see heavy public use and require extensive maintenance. Of primary concern to lake quality from this use is the introduction of nutrients from fertilizers, and toxic chemicals contained in pesticides.

Fertilizers, containing nitrates, ammonium sulfate, and potassium, can stimulate algal production if application rates are excessive, and if over-irrigation occurs. In January, 1990, a study was conducted by McCulley, Frick & Gilman, Inc. (MFG) to evaluate whether the use of fertilizers and pesticides at HPMGC could be impacting water quality at Lake Merced (See Appendix D). This study did not include the collection or analyses of either soil or groundwater samples.

The names of fertilizers and pesticides used at HPMGC were provided by the SFRPD and are listed in Table 2-2. Most of the fertilizers used on the golf courses are high in nitrate, with smaller proportions of phosphate and potash, although some fertilizers are also high in potash. Nitrogen and phosphorus are nutrients responsible for promoting algae growth in surface water bodies. Both of these nutrients could enter Lake Merced from surface water runoff from the golf course or from underlying groundwater. Phosphate is strongly sorbed to soil particles and is less likely to be leached into underlying groundwater.

MFG lists of most of the pesticides applied to HPMGC indicating their toxicity, solubility, soil adsorptivity and soil persistence (See Appendix D). Of the pesticides judged to have the highest potential to cause water quality impacts on Lake Merced are Nemacure, Trimec and Banvel. Bromoxynil is toxic to fish. Fungicides used in greatest abundance at HPMGC are low in toxicity and practically insoluble in water.

MFG personnel conducted a site visit in January, 1990, to observe the portion of the golf course perimeter that borders Lake Merced, to observe pesticide and fertilizer storage areas and pesticide mixing areas, and to interview golf course staff members regarding the use of fertilizers and pesticides. At the time of the site visit, pesticides and fertilizers were stored in a wooden shed and pesticides were mixed in an outdoor area with no provisions for containing spilled chemicals. The fairways are reportedly sprayed with herbicides (Trimec, Banvel, Roundup, and Bromoxynil) twice a year, in February and in the fall. The greens are sprayed with fungicides once per month. In general, chemicals are not applied during the rainy season in order to minimize the amount of fertilizers and pesticides that could be carried by runoff into the lake (Personal communication, Mr. Bill Del Carlo).

Application of some of the chemicals used at HPMGC is restricted by the U.S. Environmental Protection Agency (EPA) and notification of the Department of Agriculture is required prior to application. Mr. Killian of SFRPD stated that the use, storage and disposal of pesticides are supervised by the San Francisco County Department of Agriculture (SFDA). This was confirmed by MFG with Ms. Sharon Aby, a SFDA inspector, who stated that no problems in the use or storage of pesticides had been found during her agency's inspections of the golf courses.

Another parameter affecting potential migration of fertilizers and pesticides to Lake Merced is the amount of irrigation conducted. Although the quantity of irrigation water is not monitored in regard to potential irrigation return-flow, it is a policy of the golf course not to over-water, thereby causing excessive runoff or saturated conditions (Personal communication, Mr. Bill Del Carlo).

Although MFG determined that the fertilizer and pesticide application program was well managed, it is not known whether these chemicals have impacted Lake Merced water quality. To determine potential impacts to Lake Merced, a sampling program should be implemented as described further on in Section 4.

SHOOTING

The Pacific Rod and Gun Club's shooting range, adjacent to South Lake, uses the lake as a backdrop, and as a result, lead shot is introduced into the lake. A study conducted by Crosby and Overton in 1990 concluded from two lake water samples that lead is not significantly impacting Lake Merced waters, although the laboratory detection limit (0.5 mg/l) for these samples was above the drinking water standard of 0.05 mg/l. However, Lake Merced water quality characteristics (relatively high pH, and high organic, suspended sediments, and salt contents) probably preclude significant lead dissolution in lake water. Also, annual water quality sampling conducted by the SFWD shows lead concentrations below drinking water standards (Appendix C).

In March 1993, a lead characterization study was conducted for soils and sediments collected at or near the Pacific Rod and Gun Club (Ecology and Environment, March, 1993). Further discussion regarding potential lead contamination in relation to fish and wildlife is presented in Section 3.4.

2.2.4 Stormwater

There are two sources of stormwater inflow to Lake Merced. The first source is overflow from the Vista Grande stormwater conveyance culvert located between John Muir Drive and Olympic Golf Club along the southwest side of the lake. The second source is from local runoff around the lake.

VISTA GRANDE RUNOFF CULVERT

The Vista Grande runoff culvert conveys runoff from a 2.25 square-mile urban area in Daly City to an outfall station that discharges the water to the Pacific Ocean. In the Lake Merced area, the open portion of culvert generally parallels John Muir Drive between Impound Lake and the Pacific Rod & Gun Club, where it goes through a tunnel and discharges into the Pacific Ocean (See Figure 2-3). During large rainstorms (5-year events and over), runoff exceeds the culvert capacity and it spills into Impound Lake. The excess runoff is about 34 million gallons (mgal) for a 5-year storm and 53 mgal for a 25-year storm (CH2M-Hill, 1989).

Water quality of Vista Grande flows was measured in February and March, of 1984 by Kennedy/Jenks, and in January and February, 1993 by the DCDWWR (See Appendix E). The 1984 measurements were made during two moderate rainfall periods and were stated to represent first flush conditions. The sample collected in February, 1993, was preceded by a couple weeks of dry weather and was sampled within the first few hours of the storm.

The total coliform levels in stormwater averaged 220,000 MPN/100 ml 1984 (See Appendix E). Total coliform levels averaged 305 MPN/100 ml in South Lake during the 1989 through 1992 period (See Table 2-1). Turbidities in stormwater and Lake Merced are similar. Turbidity was measured in stormwater at an average of 22.5 Nephelometric Turbidity Units (NTU) in the 1984 samples and 13 NTU in the 1993 samples. Turbidities in Lake Merced averaged approximately 13 NTU in Lake Merced over the past 10 years (See Appendix E and Table 2-1). Suspended solids in stormwater averaged 44.5 mg/l in the 1984 samples and 1,750 mg/l in the 1993 samples. Suspended solids in Lake Merced averaged 13 mg/l in 1984 (See Appendix E).

Concentrations of lead, copper and zinc were higher in stormwater than in Lake Merced water. Lead concentrations in stormwater (0.038 mg/l and 0.046 mg/l, in January and February, 1993, respectively) approached the drinking water standard for lead of 0.05 mg/l. Comparison of other water quality constituents, including chloride, sodium, and total dissolved solids were considerably less in stormwater than in Lake Merced water (See Appendices C and E).

The stormwater overflow computed by CH2M-Hill would be substantially diluted in South and North Lakes, but not necessarily in Impound Lake. For a 25-year storm event, the total overflow volume is less than 6 percent of the combined capacity of South and North Lakes, even with a lake level as low as 17 feet. The resulting water level rise would be approximately 8 inches. However, the total runoff is 241 percent of the capacity of Impound Lake at that level, and the lake level would rise until water naturally flowed under the causeway into South Lake. Methods of evaluating dilution of water quality parameters are discussed in Section 7.5.

Toxicity tests that involved the testing of rainbow trout under controlled conditions indicated that trout did not display toxic responses to either non-diluted and diluted samples of the sampled stormwater runoff. The Kennedy/Jenks report concluded that, in regard to potentially discharging stormwater to Lake Merced, "the results of the analyses are favorable, particularly when considering the sampled rainfall events were preceded by extended dry periods. The runoff conditions for which samples were obtained can be considered to be representative of "first flush" conditions and would probably contain pollutants in concentrations greater than would be experienced during average wet weather runoff conditions."

LOCAL SURFACE RUNOFF

The second source of stormwater inflow is drainage from the streets and paved areas close to the Lake. As shown in Figure 2-2, Lake Merced is virtually surrounded by single-family and multi-family housing, as well as schools. Urbanization has reduced the lake's inflow through reduction of surface infiltration, especially since San Francisco requires that pavement and roof drainage be directed into the sewer system. The City's combined sewer/stormwater system has limited the impact of urbanization by diverting some pavement runoff to the ocean instead of into the lake.

A visual inspection of drainage systems around the lake and review of available utility maps suggest that gutters around approximately half the lake drain into the combined sewer/storm drain system, and therefore, do not enter the lake. The remaining area around the lake, including the entrance road into HPMGC and parking lots near Sunset Boulevard and Brotherhood Way, is assumed to drain into the lake. Along Skyline Boulevard and a small portion of John Muir Drive, stormdrains that drain directly into the lake were observed (See Figure 2-4). The observed stormdrains along Skyline Boulevard are maintained by the California Department of Transportation (Caltrans) and the two stormdrains along John Muir Drive are maintained by the SFRPD (See Photos 1 and 2).

Based on visual inspection, the total amount of paved area that drains to the lake was estimated at 18.2 acres, of which about 5.4, 10.4, and 2.4 acres are estimated to drain into South, North, and Impound Lakes, respectively.

Local surface runoff occurs every year. Allowing for 1 inch of cumulative loss to depression storage during the winter rainy season, a year of average rainfall (21 inches) is estimated to generate 2.9, 5.7, and 1.3 mgal of runoff into South, North, and Impound Lakes, respectively. These amounts are approximately 0.5, 2.2, and 5.8 percent of lake volume at low lake levels (17 feet) for the three lakes, respectively. Thus, normal runoff from perimeter streets is substantially diluted after entering the lakes, and significant water level fluctuations caused by runoff does not occur.

No quality data are available for Lake Merced perimeter road stormwater runoff. However, an indication of street runoff quality may be obtained by looking at data developed for the San Francisco Wastewater Program. As part of the effort to minimize pollutant loadings into San Francisco's combined stormwater/sewer system, a set of Best Management Practices (BMPs) have been established. These are intended to ensure that the City can comply with its wastewater plant effluent standards, which are especially difficult to meet during wet weather overflow periods (combined wastewater and stormwater).

One of the primary pollutant sources of potential concern in the Lake Merced area is automobiles because traffic is heavy, both for commuting and recreational purposes. Of concern are oil and grease deposits, tire particles, and metals from leaks, exhaust, and corrosion, all reaching roadways and parking areas, and, after rainfalls, potentially reaching Lake Merced. Baseline quality measurements have been made for the Vicente Avenue stormwater collection system, located north of Lake Merced (See Appendix F). Constituents analyzed included arsenic, cadmium, chromium, copper, lead, nickel, silver, zinc, and mercury. Compared to the proposed water quality objectives for fresh surface waters in the Bay Area, copper, lead, and zinc would appear to be the main pollutants of concern for street runoff (RWQCB, July 1992). However, it should be noted that the volume of surface runoff is very small compared with lake volumes.

2.2.5 Point Source Contamination

Discussions were conducted with RWQCB personnel regarding point source contamination that may impact water quality of Lake Merced. These discussions revealed that the only site of significant concern in the general area of Lake Merced is an underground fuel leak identified at a former Chevron gasoline station located on 3451 19th Avenue near Buckingham Way (Personal communication, Mr. Vic Pal). Portions of the case file are included in Appendix G.

The former Chevron site is located approximately 1,700 feet east of Northeast Lake. Groundwater flow direction at the fuel leak site was measured to be toward the northwest. Regional flow direction has been measured toward the west in this vicinity (Yates, 1990).

At this site, high benzene concentrations have been detected in groundwater at monitoring well C-3 (5,400 ug/l in December, 1992) and floating product was identified at monitoring well C-2. Groundwater contamination appears to be migrating generally toward the west. As of February, 1993, the floating product from the groundwater had been removed and a soil vapor extraction system was being considered for further remediation.

In regard to Lake Merced, it appears unlikely that a groundwater contaminant plume from the relatively small point source identified at the Chevron site would extend as far as the lake. However, the lateral extent of the plume has not yet been identified and it appears to extend off-site toward the west (Personal communication, Mr. Vic Pal).

2.3 IMPACTS OF RECENT REGULATORY REQUIREMENTS

Recent regulatory requirements that could impact the management of Lake Merced include the EPA NPDES permitting requirements and the Surface Water Treatment Rule. Essentially, the NPDES permitting requirements do not appear to impact stormwater discharge from San Francisco, because of their combined stormwater/sewer water system; however, the existing Wastewater Discharge Permit Program permitting requirements will have an impact. Daly City is in the process of submitting NPDES permit applications which could potentially impact the operation of the Vista Grande culvert.

The EPA Surface Water Treatment Rule virtually eliminates Lake Merced as an on-going potable source of water, without extensive treatment.

2.3.1 NPDES Permitting

The nature of stormwater runoff that can potentially enter Lake Merced may change in the future as recently enacted regulations are implemented. Controlling pollution from non-point stormwater flows has been an indirect goal of the Clean Water Act since its passage in 1972.

In 1990, EPA issued the final rules for permitting stormwater discharges. The rules targeted two categories: industry and related activities (such as construction), and large- and medium-sized municipalities with separate storm sewers, where large was defined as a population of 250,000 or more and medium as having a population between 100,000 and 250,000.

In the case of municipalities, a two-part application process was established. The application for Part I includes the following information: general (name, address, etc.), existing authorities and any additional authorities needed, source identification, discharge characterization (monthly mean rainfall, volume and quality of discharge, and list of and impact on receiving waters, and field screening for illicit connections and illegal dumping), a plan identifying proposed sampling, and a description of existing management programs and financial resources available. Large systems were to submit by November 18, 1991, while the medium system deadline is May 18, 1993.

Part II of the application includes the following: demonstration of adequate legal authority, source identification, discharge characterization data, proposed management program (Best Management Practices; BMPs), estimated reduction in pollutant loadings resulting from the management program, and fiscal analysis of the necessary expenditures. Part II deadlines are November 16, 1992 for large systems, and May 17, 1993 for medium-sized municipalities. Municipalities under a population of 100,000 are defined as small dischargers and are exempt from the law. Currently, Daly City, along with other San Mateo County cities, have submitted a NPDES Stormwater Permit Part I Joint Application to the RWQCB. Part II, which will address BMPs, is still outstanding (Letter from Mr. Lee Yarborough to Ms. Eva Vanek, December 7, 1992).

EPA has stated that they have not yet determined what cleanup steps would be required under the new program, and that they would issue a follow-up rule specifying what industries and cities would have to do to achieve the program's goal of cutting polluted runoff to the "maximum extent practicable." For cities, discharge permits probably will call for such measures as halting disposal of used oil in street drains, reducing oil and grease on roads and parking lots, improving street drain cleanup, control of illegal connections to stormwater drains, and minimizing application of pesticides and fertilizers.

Because San Francisco has a combined sewer overflow system, the stormwater regulation does not apply to it directly. Indirectly, however, the quality of "stormwater" carried by the City's conveyance system will change because it must meet somewhat similar controls under the existing EPA Wastewater Discharge Permit Program. That is, source control is incorporated in the City's Program for Water Pollution Prevention through a set of BMPs that seek to prevent pollutants from entering the waste stream. BMPs are schedules of activities, prohibitions of practices, maintenance procedures, and other management practices. Of key concern to the City are those constituents that may cause compliance problems with its NPDES permit limits. Based on the August, 1992 report "Best Management Practices Study" by JMM and Uribe & Associates, of significant concern are polynuclear aromatic hydrocarbons (PAHs), copper, lead and cyanide, while of moderate concern are cadmium, mercury, nickel, silver, and zinc. Wet weather (stormwater) BMPs therefore will focus on PAHs, heavy metals, and cyanide. As far as the quality of stormwater inflows to Lake Merced is concerned, implementation of the wastewater BMPs should enhance capture of street drainage as a result of increased cleaning of drainage channels and catch basins, and thereby reduce stormwater overflows to the lake.

With regard to the Daly City stormwater flows in Vista Grande, stormwater quality may be expected to improve upon implementation of BMPs which will address:

- Street Sweeping;
- Litter Control;
- Maintenance of Storm Drainage Facilities (catch basin, lines, etc.);
- Household Hazardous Waste Collection and Recycling of Materials.

2.3.2 Surface Water Treatment Rule

The long-standing reservation of Lake Merced as a potential potable water supply for the City of San Francisco, while providing only disinfection before introduction into the City's distribution system, must be re-evaluated in light of recent regulatory changes. Disinfection, through the use of chlorine, has been the most common water treatment process used to kill microbiological pathogens.

EPA issued the Surface Water Treatment Rule on June 29, 1989. The Surface Water Treatment Rule, implemented in California by the DOHS, under Chapter 17 of the Title 22 water quality regulations, focuses on certain pathogenic micro organisms, especially cysts, such as *Giardia Lamblia*, which are more resistant to disinfection than coliform bacteria, and may require supplemental treatment. The California State Surface Water Treatment Rule, which became effective on June 5, 1991, and which is the result of a series of amendments to the National Primary Interim Drinking Water Regulations, focuses on these micro organisms, as likely contained in surface water sources.

The Surface Water Treatment Rule specifically states that disinfection of surface sources must be complemented by filtration in order to guarantee removal and inactivation of viruses, *Giardia Lamblia*, Legionella, and heterotrophic coliform bacteria. The Surface Water Treatment Rule applies to all water open to the atmosphere and subject to surface runoff (rivers, lakes, streams, reservoirs, and impoundments), as well as subsurface waters that are directly influenced by surface water. Compliance with the removal requirements (99.9 percent for *Giardia Lamblia*, and 99.99 percent for enteric viruses) is assumed if the system complies with the treatment technique requirements specified in the Surface Water Treatment Rule.

Systems with very clean and protected source waters that have low total coliform, fecal coliform, and turbidity levels, as well as who practice specific measures, such as watershed management to maintain that quality, would be required only to disinfect, meeting residual concentration (C) and contact time (t) requirements (Ct). The DOHS determines whether a water source is subject to the Surface Water Treatment Rule requirements after following a set procedure, which includes a record review and a site inspection. "Surface water contamination" is indicated by the presence of the following: diatoms (algae), rotifers, coccidia, insect parts, *Giardia Lamblia*, and other large-diameter (>7 microns) organisms. In addition, of concern are significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH as a result of climatological or other conditions. So, for example, raw water with total coliform greater than 5,000 MPN/100 ml, and color between 40 and 75 Color Units (CU), will require complete treatment. Direct filtration (without sedimentation) should only be considered where total coliform is less than 500 MPN/100 ml; turbidities between 7 and 14 NTU; and color between 10 and 40 CU. The regulations require compliance by June 29, 1993. Exemptions are specified, but are severely limited in California.

Because of high total coliform, color and turbidity levels, the Surface Water Treatment Rule virtually removes Lake Merced as a municipal potable water supply with only the existing disinfection facility. Therefore, the SFWD has informally adopted the policy that Lake Merced would serve only as an emergency water source, accompanied by a BWO or UWA, in order to avoid its direct use as drinking water.

Section 3

BENEFICIAL USE REQUIREMENTS AND IMPACTS

Beneficial uses are set forth in the San Francisco PUC Resolution No. 10,435 dated January 30, 1950 and in the 1986 RWQCB San Francisco Bay Basin Plan (Basin Plan) (See Appendix A and H). The PUC Resolution states that "the primary purpose of the Lake Merced Tract is to supply potable water to the water consumers in San Francisco." As described in Section 2, Lake Merced has been recognized by the SFWD primarily as a source of emergency water supply since the 1930s. The PUC Resolution recognized, however, that in addition to potential water supply, the lake should also provide park and recreational benefits to the City, and therefore the Resolution conferred upon the SFRPD the right to develop and administer the area with both benefits in mind.

According to the Basin Plan, Lake Merced is listed as a municipal water source (potential), as a water-contact recreational source (REC-1, with the provision to include only "fishing from shore or boat allowed; no other recreational use permitted"); a non-water contact recreational source (REC-2); as a warm fresh water habitat (WARM) and a cold fresh water habitat (COLD); as a wildlife habitat (WILD); and as a fish spawning habitat (SPWN).

This Section describes the requirements of 1) emergency water supply, 2) water-contact and non-contact recreation, and 3) fish and wildlife habitat in regard to lake level and quality, and the impacts of beneficial uses on each other. Lake Merced water levels have been described relative to an on-site gauge board, City datum, and mean sea level (MSL). Gauge board measurements are 8.76 feet higher than mean sea level (MSL) and 17.50 feet higher than City Datum (SFWD, September 1951). In this study, all lake measurements referenced are relative to the gauge board, unless otherwise indicated.

3.1 EMERGENCY WATER SUPPLY

3.1.1 Background

Lake Merced was used as a potable water supply during the late 1800s and early 1900s by the Spring Valley Water District. In 1930, the City acquired the land, and, in 1910, Lake Merced was relegated to an emergency water supply source when the superior Hetch Hetchy water was made available to San Francisco.

In 1950, the status of Lake Merced as a potential potable supply was formally set forth in the PUC Resolution which states that as a potential potable water supply, swimming and gasoline-driven motorboats are prohibited; all sewage be removed from the lake area; no more than the average yield of the lake be withdrawn, that the lake level not be allowed to drop below Elevation 27 feet; and that nothing should be permitted that is detrimental to the quality or use of the water in Lake Merced.

Other pertinent water supply regulations and guidelines include the 1) RWQCB Basin Plan which lists Lake Merced as a "potential municipal" beneficial use, and provides accompanying water quality objectives, and 2) the RWQCB "Proposed Groundwater Amendment to the Water Quality Control Plan, San Francisco Region," which also provides accompanying water quality objectives. The ramifications of RWQCB criteria will be discussed in Section 3.1.3.

potable unless it were treated by filtration as well as by disinfection. However, Lake Merced is listed as a "potential municipal" supply under the RWQCB Basin Plan. As an existing municipal supply, specific water quality criteria, particularly for color, odor, turbidity and various inorganic constituents, would need to be met. As a potential municipal supply, water quality criteria are undefined.

As Lake Merced is an exposure of the groundwater table, water quality criteria pertaining to groundwaters of the State may also be applicable to Lake Merced (RWQCB, July, 1992). Unless otherwise designated by the RWQCB, all groundwaters are considered suitable, or potentially suitable, for municipal or domestic water supply (MUN). Four categories of exceptions are set forth by the RWQCB. Of these exceptions, one may apply to Lake Merced. The exception is stated as follows:

> *"There is contamination, either by natural processes or by human activity (unrelated to a specific pollution incident), that cannot reasonably be treated for domestic use using either Best Management Practices or best economically achievable treatment practices."*

At Lake Merced, contamination results from characteristics of the lake as a natural impoundment (high algae, turbidity levels). Additionally, the use of the lake as a recreational facility and its presence as a habitat to a wide variety of fish and wildlife induces coliform bacterial contamination. Thus, the exception noted above may apply to Lake Merced.

Most importantly, Lake Merced is listed as an emergency water source under the draft Emergency Operations Plan (EOP) prepared for the SFWD by EQE Engineering and Design (EQE, December, 1992). Within the EOP, Lake Merced is listed as one source of water that could supply emergency water for emergency response activities such as firefighting. Other non-potable uses of lake water could also include sanitary controls.

Conversations with SFWD and SFFD personnel indicate that Lake Merced water could be pumped for firefighting 1) directly from the lake, 2) from cisterns using a pumping relay system, or, most likely, 3) by the Lake Merced Pump Station where water would be distributed into the Sunset and Sutro Reservoirs. From the reservoirs, lake water could compromise drinking water through the normal City water distribution system or by SFDPW tanker trucks. In the event that drinking water could not be distributed through existing pipelines, the water would be obtained by tanker trucks from local hydrants and distributed to San Francisco residents directly (EQE, December, 1992).

It is recognized by the California Department of Health Services (DOHS) that an alternate water source could compromise the drinking water distribution system. Therefore, the DOHS Office of Drinking Water (ODW) has recently issued guidelines for use of alternate water sources and the issuance of UWAs and BWOs as part of a Disaster Response Plan (DOHS, May, 1992). These guidelines conform to requirements of Section 4029 of the California Safe Drinking Water Act. The policy set forth in the DRP which has been adopted by the SFWD states:

> *"The use of compromised water sources can be approved during emergencies. Approval should be based upon specific conditions when all other safe alternatives have been exhausted. The use of surface water with disinfection only must be implemented in conjunction with a Boil Water Order (BWO) or an Unsafe Water Alert (UWA). The intent of this policy is to ensure that the public health and safety always takes priority during an emergency, and when available*

algae (Personal communication, Mr. Ron Carlin). At present, Lake Merced is not treated for algae. To date, the DFG has not permitted the use of algicide in Lake Merced because of the potential damage to the stocked trout from copper precipitation.

Copper sulfate dosage has been successfully reduced in reservoirs by mixing it with citric acid in a two-to-one ratio. The citric acid prevents the precipitation of copper. An alkaline water, (greater than 150 mg/l), such as the waters of Lake Merced, is required for use of citric acid. Carlin indicated that the results of copper sulfate or citric acid treatment can be seen within 24 hours. Thus, it appears that pre-treatment to reduce algae could be conducted just prior to distributing lake water within the City distribution system rather than initiating it on a regular basis. The restricted use of copper sulfate just prior to distribution during emergencies could be presented to the DFG for approval, and included in a Emergency Operations Plan for the lake, if allowed.

In the event that both disinfection and copper sulfate treatments are used at Lake Merced, it is possible that its status of emergency water supply could be raised to first choice.

3.2 RECREATIONAL USES

3.2.1 Background

The following information was compiled through a series of interviews with managers of various recreation uses at Lake Merced, including Chris Senti of the Lake Merced Boating and Fishing Company, Michael Proctor of the Pacific Rod and Gun Club and Deborah Learner and Bob Killian of the SFRPD. In addition, field visits to the lake were conducted by Public Affairs Management (PAM) to observe use patterns and recreational activities.

Information was also obtained from the 1990 Draft "Lake Merced Recreation and Open Space Plan" which reviewed the characteristics of the lake including its vegetation, wildlife, fishery, recreational uses, and existing facilities (DPW-BOE, 1990). The plan set forth objectives, policies, and recommended actions intended to preserve and enhance the diverse recreational opportunities and to retain the lake as a potential emergency municipal water source.

FISHING

Fishing at Lake Merced is allowed seven days a week, from one hour before sunrise to one hour after sunset, all year long. Approximately 60,000 to 70,000 fishermen use the lake annually. The highest use period occurs in the mornings during weekends in spring, summer and fall, with 225 to 250 fisherman per weekend day. During the week, the number of fishermen drops to about 150 per mid-week day. A wide range of people fish at Lake Merced; from retired people, to serious sport fishermen, to youth groups.

Fishing generally takes place from designated shorelines, fishing piers, float tubes and boats in both the Northwest and South lakes. The lower water levels in the North Lake have restricted the ability of boats to pass through the channel between the Northwest and Northeast lakes, thereby reducing the fishing in the Northeast Lake. In addition, shore access to the Northeast lake is restricted. A state fishing license and a separate daily fishing permit are required for fishing in the North. Annual permits are available for the South Lake only.

Fishing in the shallow Impound Lake is only allowed from the shoreline in areas not lined by tule reeds. In September 1992, water levels in Impound Lake were so low that the fish population was threatened. To save fish in this lake, water was pumped from the South Lake into Impound lake by

SFWD (Personal communication, Mr. Bob Killian, 1992).

Both South and North Lakes provide trout fishing all year long. Trout fishing is best in spring and fall, but mild temperatures keep water conditions optimum throughout the summer as well. The North Lake is stocked by the Lake Merced Boating and Fishing Company with trophy-sized trout ranging from 2 to 17 pounds. The DFG also plants the North Lake with approximately 4,000 smaller fish (1 to 1 pounds) per month. DFG plants approximately 60,000 trout (1 to 2 pounds) per year into the South Lake. The South Lake is also occasionally stocked with larger trout (3 to 5 pounds).

Although rainbow trout is the most popular fish at Lake Merced, accounting for 90 percent of all catches, naturally occurring black bass, catfish and carp are also fished. The daily catch limit at Lake Merced is 5 trout, 5 bass and 10 catfish, with no limit on carp.

Special programs are offered by the Lake Merced Boating and Fishing Company. Fishing derbys run periodically throughout the year, and prizes are awarded for the largest trout. Every month approximately 40 to 50 trout are released with tags. Each tag is worth a prize if returned to the main office.

Fishing activities on the lake are operated by the Lake Merced Boating and Fishing Company, located on Harding Road between the North and South Lakes. This company offers boat rentals, fishing equipment rentals and sales, fishing permits, private boat storage and launching, fish stocking and special fishing events. The company employs about 15 full- and part-time employees on a seasonal basis.

BOATING

Next to fishing, boating is the second most active recreational use at Lake Merced, mostly occurring from afternoon to evening. Types of boating activities allowed on both North and South lakes include row boats, fishing boats, paddle boats, canoeing, and sailing. Sculling is only allowed on the South Lake. No boating is allowed on Impound lake. No gasoline-powered boats (except emergency patrol boats) are allowed on the lakes, and electric motor boats are only allowed on the North Lake. Private boats may be launched and stored on Lake Merced for a daily or annual fee.

During the week, most boating activities center around fishing, with some sculling and sailing. On weekends, more use is devoted to pleasure boating (sailing, paddle boats, row boats, and canoes) rather than fishing. Approximately 40 boats are available for rent, and it is not unusual during the weekend to have all 40 on the water with 10 additional private boats.

Several organized groups use the lake for rowing and sculling practice: Saint Ignacio High School, Pacific High School, UC San Francisco, the Dolphin Club, the South End Rowing Club, and others. Equipment and boats for these clubs are stored under the Boathouse Restaurant, located next to the Lake Merced Boating and Fishing Company's office.

Boating activities on the lake center around the Lake Merced Boating and Fishing Company. This company rents boats and equipment every day of the week, offers storage for private boats, provides boat launching facilities, docks, a boat hoist (which is no longer usable due to low water levels), and safety/rescue patrol of the lake.

GOLFING

HPMGC is a public golf course established in 1925. It is the only public 18-hole golf course located in the southwestern area of San Francisco. The Olympic Country Club, the San Francisco Golf Club and the Lake Merced Golf and Country Club, all private, are located within two miles of HPMGC. The HPMGC, which is located at the east end of Harding Road, consists of two courses. Harding Golf Course is an 18-hole, par 4 regulation course covering 6,586 yards. The boundaries of six of Harding's holes are set by Lake Merced. Fleming Golf Course, a separate 9-hole, par 3 "executive" course, covers 2,316 yards and is located within the front nine holes of Harding.

The HPMGC totals about 150 acres, with 71 acres of usable (turf) area. It is a heavily used facility, with over 110,000 rounds of golf played on Harding and 80,000 rounds played on Fleming in 1991. During the busiest times, about 32 players an hour are sent onto the course.

The HPMGC is open 7 days a week during daylight hours, all year long. The busiest periods are on weekday mornings, when prices are lower and more retired citizens play, and on weekend mornings, when younger golfers play.

A driving range, three practice putting greens, pro shop and club house (with restaurant and lounge) are also located within the golf course complex. The pro shop offers equipment sales and rentals, golf cart rentals, private lessons and golfing classes. Special events, such as tournaments and fund raisers, are offered throughout the year. High school teams and classes are allowed use of facilities at Harding Park.

The golf course employs 8 full-time gardeners who are responsible for maintenance of the greens, fairways, rough areas and trees. A maintenance shed located southeast of the golf course parking lot houses mowers, chippers, fertilizers and pesticides. fertilizer and pesticide application is discussed in Section 2. Grass clippings and wood chips are applied to turf areas to control weeds (Personal communication, Mr. Bill Del Carlo). Turf management practices are described by MFG (See Appendix D). In general, chemicals are not applied during the rainy season to minimize the amount of pesticides and fertilizers that could enter the lake through runoff from the course. Water use for irrigation is significantly reduced on cooler days when humidity is higher, and no irrigation occurs during the rainy season (Personal communication, Mr. Bob Killian).

Irrigation of the golf course used to be provided by either an on-site well or a pump located in the South Lake, near the intersection of Harding and Skyline. The well has not been used for some time and the golf course stopped pumping irrigation water (approximately one foot per year) from Lake Merced in 1990, after low lake levels made the pump inoperable (Personal communication, Mr. Mark Siegenthaler). Irrigation water is now provided by the City distribution system.

GUN CLUBS

The Pacific Rod and Gun Club, Inc. (established in 1934) is located along the shores of the South Lake on John Muir Drive. The club is open to the public and has over 500 active members. The hours of operation are 11:00 A.M. to 5:00 P.M. every Wednesday, Saturday and Sunday, and all National holidays (except Memorial Day). On an average day, approximately 100 to 125 people use the club facilities.

The Pacific Rod and Gun Club normally utilizes water from Lake Merced for irrigation of turf and landscaped areas. However, because of the low level of the lake, the Club's irrigation pump inlet is currently above the water level and not usable.

The Pacific Rod and Gun Club encompasses approximately 13 acres of land consisting of shooting fields and ranges, parking areas, meeting halls and other facilities. In addition, the Club also covers approximately 12 acres of the lake as a safety zone within which boaters are not allowed during shooting. The safety zone is delineated by buoys. Club facilities include 8 skeet fields, 3 trap fields, a small bore rifle range and a clubhouse. Because of their facilities, the club is authorized to hold nationally and internationally sanctioned competitions. Currently, the club hosts 13 formal competitions per year which average about 100 participants. Courses in firearms and hunting safety are offered from December through September.

A clubhouse on the grounds is available to rent for meetings, dinners, and parties. Several events, such as dinner-dances and barbecues, are held throughout the year. The Club also allows other Bay Area groups, such as the San Francisco Tennis Club, the Olympic Club, and corporate groups, to use their facilities for shooting events or meetings. The Pacific Rod and Gun Club is one of only three gun clubs in the Bay Area. Others are located in Martinez and Redwood City.

The San Francisco Police Department indoor pistol range is located just west of the Pacific Rod and Gun Club, at the intersection of John Muir Drive and Skyline Boulevard. This facility is not open to the general public.

OTHER RECREATIONAL USES

Windsurfing classes (beginner through intermediate), equipment rentals, and certification are offered by the San Francisco School of Windsurfing (established in 1988), which only operates on weekends from spring through fall. Windsurfing is allowed only on the South Lake. Lake Merced is a popular lake for beginning windsurfers because of its mild, consistent breezes.

Running, jogging, and walking occur mostly around the perimeter of the lake on the paved trail. The trail around the perimeter of the lake is proposed to be widened to 12 feet to accommodate the heavy recreational use. A circuit training course is located along the west and north boundaries of the lake. Paved and dirt paths lead down to the water's edge on the southern edge of the Northwest Lake and between the South Lake and Impound Lake. The western beach at the southern end of the South Lake was recently cleared of tall weeds and brush and filled with gravel and sand to smooth and extend the shoreline, as well as provide access for fish stocking and emergency water pumping equipment (Personal communication, Mr. Bob Killian). A narrow footpath is located on the bluff overlooking the Northeast Lake.

Bicycling is another activity which takes place mostly on the paved trails along the perimeter of Lake Merced and on designated bike paths along Skyline Boulevard, from John Muir Drive to Sloat Boulevard. Bike trails and lanes around Lake Merced connect to other regional bike trails along the Great Highway, Sloat Boulevard and Sunset Boulevard. Bicycle races and bike club tours often take place around the lake.

Rollerskating and rollerblading also take place on paved paths around the lake. Skaters and rollerbladers generally use the same trails as bicyclists. However, the trails at Lake Merced are best for rollerblading because the pavement is uneven, cracked and rocky in certain areas, whereas smooth concrete is generally best for rollerskating.

Bird watching is popular along the trails and shoreline of Impound Lake. Shore birds (gulls and sandpipers); water birds (ducks); and wading birds, including great blue herons, great egrets and snowy egrets, are seasonally common in this shallow lake. Groups of bird watchers often gather along the eastern end of John Muir Drive with binoculars and spotting scopes during weekend mornings. Feeding the ducks and gulls is also a common activity along the southern shore of the South Lake.

Established picnic areas are located on Harding Road between the North and South

Lakes, at the Lake Merced Boating and Fishing Company. These picnic grounds include 12 picnic tables, 6 barbecues, grassy and shady areas, and nearby parking. A smaller picnic area (only a few tables) is located between the South Lake and Impound Lake, near the eastern edge of the bridge. Picnic grounds at Lake Merced are generally crowded on summer weekends and holidays during good weather. Picnickers often participate in other activities at the lake, such as boating, fishing or golfing.

The Boathouse Restaurant, located on Harding Road between the North and South lakes, offers dining all day long and entertainment at night. Banquet facilities are available for rent from the restaurant and parking is available nearby. However, parking is often limited on weekends due to the large number of people using the facilities at Lake Merced.

3.2.2 Water Level Criteria

As a result of historically declining water levels, recreational uses at Lake Merced have experienced a number of problems related to low water levels. Less surface area on the lake has reduced the area available for recreational uses and resulting changes in shore vegetation (increased tule growth) have affected the use of recreational facilities and aesthetics of the lake. In most cases these problems could be alleviated by raising the water level of Lake Merced. Figure 3-3 shows areas of impacts to recreation due to declining lake levels.

FISHING

Low water levels on Lake Merced have resulted in a decrease in the quality of recreational fishing. Currently many of the fishing piers located around the lake have become overgrown with shoreline vegetation (primarily tules) as a result of the low water level. This situation has resulted in a significant reduction in the usability of these facilities. One pier, the children's fishing pier located near the Lake Merced Boating and Fishing Company, has been closed due to the low water level and damage that occurred to the pier because it is now on dry land (See Photo 7). The low water level has also resulted in the exposure of shoreline areas for fishing which in some cases has lead to erosion (See Photos 8 and 9).

Fish-eating birds observed by Jones and Stokes Associates, Inc. (JSA) in September 1992, include belted kingfishers; brown pelicans; double-crested cormorants; gulls; and western, eared and pied-bill grebes. Cormorants have been observed feeding on trout planted in Lake Merced and are thought to have reduced the number of trout in the lake (Personal communication, Mr. Chris Senti). The relationship between lake levels and the success rate of fish-eating birds is discussed in Section 3.3.

To improve fishing conditions at Lake Merced, lake levels should be restored to a minimum of 21 feet to a maximum of 26 feet. That range of lake levels would float fishing piers and improve fishing boat access to the Northeast Lake by widening the channel between the Northwest and Northeast Lakes. Due to height and size limitations of fishing piers, shorelines and boating facilities, water levels higher than 26 feet would result in an adverse impact on fishing piers (Personal communication, Mr. Chris Senti).

BOATING

Low water levels have resulted in adverse impacts on boating operations at Lake Merced. Portions of all docks are setting on land, resulting in very steep ramps, loss of dock and boat storage space, and stress damage to docks (See Photos 10 and 11). Currently, the North Lake launch ramp is out of the water and not usable. Also, there is not enough water under the boat hoist to launch boats or pull boats out of the water (See Photos 12 and 13).

Sailboats have run aground 50 yards from shore and rowers have hit obstacles sticking out of the water. In addition, tule and weed encroachment is reducing the surface area of the lake and has nearly eliminated boat access to the Northeast Lake.

To improve boating conditions, the lake level should be restored to a minimum of 21 feet to eliminate obstacles in shallow areas, reduce the steep angle of dock ramps, eliminate stress on the docks, and to allow the boat hoist and launch ramp to be used. Recreational boating access to the Northeast Lake would also be improved by the addition of water.

A lake level of 26 feet would bring all boating, rowing and windsurfing facilities into full operation. Due to height limitations of boat docks, boat ramps, the boat hoist and boat storage areas, a lake level rise above 26 feet would adversely impact these facilities (Personal communication, Mr. Chris Senti).

GOLFING

Although current operation of the golf course is not directly related to lake levels, some aspects of the golf course have recently been affected by low lake levels. Hole #18 at Harding Golf Course used to be played over a water-filled inlet of the lake. However, due to low lake levels, this inlet is no longer filled with water, and consists mostly of tall weeds and shrubs. In addition, the quality of views of the lake from within the golf course have declined as water levels have decreased.

Irrigation pumps formerly used by the golf course were closed down in 1990 when lake levels dropped to 19 feet. At that level, the pump intake was only about two feet horizontally into the lake and the pump was sucking in sand. The pump intake should be submerged at least 4 feet into the lake to operate the irrigation pump (Personal communication, Mr. Mark Siegenthaler). It is estimated that a minimum lake level of 23 feet would be required for the operation of the pump. Currently, the golf course uses the City distribution system for irrigation. The golf course does not have an agreement regarding future use of the pumps for irrigation.

PACIFIC ROD AND GUN CLUB

The Pacific Rod and Gun Club is currently unable to use their irrigation pump located in the north inlet of their property because the pump is out of the water. A lake level of 21 feet would be required to make the irrigation pump operational. There is no written agreement between the Gun Club and the SFWD regarding use of the pump.

Low lake levels have reduced the aesthetic quality of the shooting ranges. However, a lake level in excess of 27 feet would flood the southern end of the shooting field (Personal communication, Mr. Mike Proctor).

AESTHETICS

Other recreational uses, such as walking, running, bicycling and picnicking are not directly affected by water levels at Lake Merced. However, current water levels have resulted in decreased aesthetic quality of views, weed encroachment and unpleasant smelling water primarily from algae blooms which appear to have increased with the lower lake level (Personal communication, Mr. Chris Senti). Optimal water levels for these recreational activities are difficult to quantify because they are non-water contact activities and are not directly affected by lake levels. However, to improve aesthetics for walkers, runners, bicyclists, picnickers, an optimal water level is considered to be similar to optimal levels for fishing and boating (21 to 26 feet).

Lower water levels have resulted in some benefits to other recreational uses. The beaches between the South Lake and Impound Lake are increasing in size due to the receding water. This is a popular location for shoreline fishing, walking, and duck feeding.

Optimal water levels for duck feeding are based on optimal lake levels for dabbling ducks (those ducks that loaf in deep pools and forage in shallow water). Optimal conditions for dabbling ducks can be attained at approximately 8 feet in South Lake, 11 feet in North Lake and 15 feet in Impound Lake (See Section 3.3).

Low water levels in Impound Lake have also resulted in increased opportunities for bird watching, as more wading birds, such as herons and egrets, are visiting the mudflats near the southern shore. Optimal conditions for marsh habitat can be attained at approximately 5 feet in South Lake, 11 feet in North Lake and 13 feet in Impound Lake (See Section 3.3).

3.2.3 Water Quality Criteria

General objectives for inland surface water bodies are set forth by the RWQCB in their 1986 Basin Plan and are included in Appendix H. The Basin Plan sets forth general objectives for color, taste, odor, floating material, suspended material, sediment, biostimulatory substances, salinity and oil and grease. More specific objectives are recommended for pH, dissolved oxygen, coliform bacteria, temperature, toxicity, un-ionized ammonia, and sulfide. However, most of these criteria (turbidity, pH, temperature, salinity, un-ionized ammonia, and sulfide) specifically refer to concentrations created by controllable water quality factors (such as discharge of wastewater). Objectives for dissolved oxygen are provided for cold and warmwater habitats. Objectives for total coliform are provided for water-contact recreational activities but not non-contact activities. Objectives for fecal coliform are provided for both contact and non-contact activities.

FISHING

Low water levels are believed to have resulted in a decrease in general water quality at Lake Merced. Algae blooms, which are more predominant at low lake levels, have resulted in musty tasting fish, foul smelling water, and poor water clarity, which impacts the quality of fishing at Lake Merced. Apparently, the DFG has been unable to plant trout lately because of the low water levels and low oxygen levels (Personal communication, Mr. Chris Senti). Warmer water temperature resulting from low water levels is also threatening the trout population (Letter from Mr. Chris Senti to SFRPD, 1990).

The RWQCB water quality objectives that appear to be exceeded in relation to fishing, particularly during the summer, include color, taste, odor, floating material, sediment, turbidity, dissolved oxygen and temperature (Written communication, Mr. Chris Senti, May 10, 1993).

As a non-contact water recreation sport, there is a possibility that the water quality objective for fecal coliform is exceeded for fishing. Currently, only total coliform is measured and no standard for total coliform is set forth for non-contact sports in the Basin Plan. However, the Basin Plan does stipulate that fecal coliform should not surpass a mean of 2,000 MPN/100 ml. Total coliform has been reported at Lake Merced as high as 4,425 MPN/100 ml in December, 1991 and 13,000 MPN/100 ml in 1984 (See Table 2-1 and Appendix E). Thus, it is possible that fecal coliform criteria are exceeded at Lake Merced.

BOATING

Boating for sport fishing is considered a water-contact recreation sport while pleasure boating is considered a non-contact recreation sport. The RWQCB water quality objectives that appear to be exceeded in relation to both kinds of boating, particularly during the summer, include color, odor, floating material, sediment, and turbidity (Written communication, Mr. Chris Senti, May 10, 1993). As above, the water quality objective for fecal coliform may also be exceeded.

In regard to boating for sport fishing, RWQCB water quality objectives for total coliform state that no sample should exceed 10,000 MPN/100 ml and that the median concentration should be less than 240 MPN/100 ml. Examination of Table 2-1 indicates that samples collected during the 1989-1992 period did not contain total coliform up to 10,000 MPN/100 ml and the median over that time interval was less than 240 MPN/100 ml. Total coliform did exceed 10,000 MPN/100 ml in 1984 when it was measured by Kennedy/Jenks at 13,000 MPN/100 ml (See Appendix E). It should be noted that the timing of sample collection conducted by SFWD varies slightly with the timing recommended by the RWQCB.

WINDSURFING

Windsurfing is considered to be a "light body" water-contact recreational sport. As such, RWQCB general water quality objectives apply, as well as objectives for total coliform. The general RWQCB water quality objectives that appear to be exceeded in relation to windsurfing, particularly during the summer, include color, taste, odor, floating material, sediment, and turbidity (Written communication, Mr. Chris Senti, May 10, 1993).

AESTHETICS

Other recreational uses, such as walking, running, bicycling, picnicking, bird watching, golfing and shooting are not directly affected by water quality at Lake Merced. However, current water quality conditions have resulted in unpleasant smelling water primarily from algae blooms which appear to have increased with the lower lake level (Personal communication, Mr. Chris Senti). Thus, RWQCB general objectives exceeded in relation to aesthetics, particularly during the summer, include color, odor, floating material, sediment, and turbidity (Written communication, Mr. Chris Senti, May 10, 1993).

3.3. FISH AND WILDLIFE HABITAT

3.3.1 Background

Prior to development, Lake Merced likely contained native populations of estuarine fish, possibly including tidewater goby. To evaluate current conditions, JSA collected information regarding existing vegetation and wildlife uses of Lake Merced and the shoreline areas, including use by special-status species. A JSA wildlife biologist conducted a reconnaissance field survey of the lake on September 19, 1992.

FISHERIES

Information on fishery resources of Lake Merced is based on DFG file data and discussions with DFG and Lake Merced Boating and Fishing Company personnel. Fishery resources of Lake Merced consist of populations of both warmwater and coldwater species. Table 3-1 presents fish species known to occur within Lake Merced. DFG manages Lake Merced primarily as a "put-and-take" fishery for planted rainbow trout although a limited warmwater fishery exists.

Unlike rainbow trout populations, warmwater fish populations in Lake Merced are maintained entirely by natural reproduction. Channel catfish, largemouth bass, and redear sunfish were introduced into the lake in 1976, and catfish were added again in 1986, but there is no regular stocking program for warmwater fish.

Naturally occurring limnological conditions (relatively cool water temperatures) and lack of optimal spawning habitat (steep shorelines, lack of underwater structure) likely limit warmwater fish production in Lake Merced. Largemouth bass require relatively flat, shallow (usually less than 10 feet deep) bottom areas in which to spawn successfully. Nests are constructed on lake bottoms over a variety of substrate types, including gravel, sand, vegetation, mud, and cobble. Nests are constructed in quiet-water habitats where they will be protected from wave erosion.

VEGETATION

Vegetation descriptions from a previous inventory of natural resources of Lake Merced (Robilliard and Stromberg, 1987) were compared with observations during the 1992 field survey. In general, there appeared to be little difference in vegetation distribution and quality between the two survey periods, as discussed below and shown in Figure 3-4. Wildlife species observed during the field survey, or with potential to occur at Lake Merced, are shown in Appendix I.

The vegetation around the margin of Lake Merced consists of a mosaic of upland and wetland vegetation types that occur as a series of linear bands. The upland types are dominated by non-native species but the wetland types consist of mostly native species.

The upland vegetation mosaic includes types dominated by trees, shrubs, and herbaceous species. The tree dominated types include taller cypress, pine, and eucalyptus forest; mixed forest types, including one or more of these species; and shorter types dominated by albezzia or one or more species of acacia. Significant bank erosion and bank slumping occurs on the northeast shore of South Lake. At one location along the western shore, shoreline slumping has damaged part of Skyline Highway.

Shrub types are dominated by blackberry, yellow-bush lupine, or coyote bush, a mix resembling natural coastal scrub. The herbaceous types are ice plant and a mix of rank forbs and annual grasses.

The wetland vegetation types are dominated by willow, California tule, and water smartweed. The tules form an almost continuous band around South and North Lakes. Tules have extended approximately 5 feet upslope of the recently built fishing piers (Personal communication, Mr. Scott Knepper). Using aerial photographs, Robilliard and Stromberg determined that there was a moderately wide band of tules in 1948, a narrow, broken band in 1964, and a wide band (150 feet in many places) nearly surrounding the lake in 1987 (Robilliard and Stromberg, 1987). In 1992, the width of the tule band generally appeared smaller than in 1987. These changes do not correlate in an obvious way with lake level and it is not known whether other activities, such as tule thinning by man, may have occurred during that time.

The biggest change in vegetation between 1987 and 1992 was at Impound Lake where tules have died and receded from the water's edge and new willow growth has taken over. Impound Lake is the shallowest of the three lakes and was almost dry during the JSA field survey.

WILDLIFE

Water Birds. Water bird use of the lakes varies seasonally and with water depth. Deep-water habitat is available for diving ducks, such as bufflehead, ruddy duck, canvasback, and lesser scaup. These species tend to be present from October to March as long as the water is deep enough (more than 3 feet) to satisfy their habitat and feeding requirements. Dabbling ducks, including mallard, cinnamon teal, American wigeon, and northern shoveler, loaf in deep pools and forage in shallow water. Mallards, pied-bill grebes, and occasional ruddy ducks are known to breed at Lake Merced (Personal communication, Mr. Dan Murphy).

Migrating shorebirds that occur infrequently include semi-palmated plover, greater and lesser yellowlegs, and spotted sandpiper. The killdeer occurs year round and probably nests at Lake Merced. The shallow water and mudflats at Impound Lake provide shorebird feeding habitat; however, this habitat is atypical and would not exist at normal (higher) lake levels. The other lakes are deeper with minimal open shoreline habitat suitable for shorebirds.

Resident wading birds are present all year. Wading birds observed during the JSA field survey include the great blue heron, great egret, snowy egret, green-backed heron, and black-crowned night-heron. These birds were observed foraging in the shallow waters in Impound Lake. Great blue herons and black-crowned night-herons were also observed roosting in the eucalyptus grove on the south shore of South Lake and on tules along the water's edge. Green-backed herons, Virginia rails, and soras are known to nest in the marsh habitat at Lake Merced (Personal communication, Mr. Dan Murphy).

Fish-eating birds observed during the field survey included belted kingfishers; brown pelicans; double-crested cormorants; several gull species; and western, eared, and pied-bill grebes. Approximately 25 cormorants were roosting in the eucalyptus grove on the south shore of South Lake. Cormorants have been observed feeding on trout planted in Lake Merced and are thought to have reduced their numbers (Personal communication, Mr. Chris Senti). Comorants typically catch fish of no commercial value (Terres, 1987) but will take advantage of an abundant prey source that occurs during fish stocking in lakes. Ospreys also have been occasionally observed at Lake Merced in recent years (Personal communication, Mr. Dan Murphy).

Other Avian Species. Other avian species include over 50 bird species known to nest at Lake Merced (Personal communication, Mr. Dan Murphy). Emergent wetland vegetation provides foraging and nesting habitat for resident and migratory birds, including northern flickers, marsh wrens, black phoebes, tricolored blackbirds, and red-winged blackbirds. Riparian scrub vegetation near the water supports several species of warblers, ruby-crowned kinglets, saltmarsh common yellowthroats, and many other songbirds. The herbaceous ground cover on the bank slopes provides foraging or breeding habitat for white-crowned sparrows, western meadowlarks, and American kestrels. The non-native eucalyptus trees on the higher slopes provide plenty of insects for wintering and migrant warblers.

Several of the bird species observed in upland habitats include red-shouldered hawks, red-tailed hawks, Anna's hummingbirds, scrub jays, chestnut-backed chickadees, and red-breasted nuthatches.

Aquatic and Amphibious Organisms. The mudflats observed at Impound Lake and shallow water areas around the other lakes are expected to support a high density of invertebrates that attract wading birds, shorebirds, feeding gulls, and fish. Pacific treefrogs and western toads would be expected to occur along the shallow lake edges but none were observed during the JSA field survey.

Mammals and Reptiles. Mammals expected to occur in upland habitats are species that have adapted to urban environments, such as squirrels, mice, gophers, rats, bats, rabbits, skunks, and raccoons. A gray fox was killed on a road adjacent to the park (Personal communication, Mr. Ed Ely) and Mr. Dan Murphy has observed long-tailed weasels and red fox at Lake Merced. Bowls of food and water inside upturned boxes were observed in shrubs along North and Impound Lakes during the field survey. They apparently were intended for feral cats which prey on native birds and other wildlife.

Western fence lizards, northern alligator lizards, ringneck snakes, and coast garter snakes are expected to occur in terrestrial habitat around the lake shore, and rubber boas were common along the east side of South Lake before development (Personal communication, Mr. Ed Ely).

3.3.2 Special-Status Wildlife Species

Sixteen special-status wildlife species are known to occur or have potential to occur at Lake Merced (DFG, 1992; Personal communications, Mr. John Brode, Mr. Ed Ely, Mr. John Hafernik, Mr. Sam McGinnis, and Mr. Dan Murphy).

The state-threatened bank swallow nested at Lake Merced through the 1930s; but in the late 1930s, the bank swallow nesting colony was lost when the lake was scoured of vegetation, enlarged, and the water level raised (Personal communication, Mr. Dan Murphy). Bank swallows currently nest at Fort Funston, less than 0.25 mile from Lake Merced. Lake Merced's freshwater marsh habitat and plentiful source of insects provide ample foraging opportunities and is considered a critical food source for bank swallows during the breeding season (Personal communication, Mr. Dan Murphy).

The saltmarsh yellowthroat is a candidate species for federal listing as threatened or endangered. Approximately 20 pairs recently nested along the shore of Lake Merced (Personal communication, Mr. Dan Murphy). According to the Draft Lake Merced Recreation and Open Space Master Plan, the saltmarsh yellowthroat nest along the banks of North and East Lakes (DPW-BOE, 1990). The yellowthroats' territories include the riparian woodlands around the lakes and the freshwater marsh.

Special-status bird species that occur occasionally but do not nest at Lake Merced include brown pelicans, ospreys, Cooper's hawks, sharp-shinned hawks, loggerhead shrikes, and tricolored blackbirds (Personal communication, Mr. Dan Murphy). The California black rail was last observed at Lake Merced in 1937 (DFG, 1992) and is not expected to occur there now.

The federal and state endangered San Francisco garter snake was a historical resident at Lake Merced but is not expected to occur there now (Personal communication, Mr. Sam McGinnis). Several factors probably contributed to the loss of this snake at Lake Merced, including increased urbanization and loss of upland burrow retreats, lake and vegetation scouring in the 1930s, and the loss of red-legged frog populations, which are a major prey item for the species.

There are records of California red-legged frogs at Lake Merced as recently as 1976 (Personal communication, Mr. Ed Ely). The California red-legged frog is a federal candidate species and a state species of special concern. The U.S. Fish and Wildlife Service (USFWS) has been petitioned to list the red-legged frog as endangered. Open water and tule and willow vegetation provide suitable habitat for the red-legged frog. The presence of fish, and possibly bullfrogs, however, reduces the habitat quality and may be the cause of their decline. Surveys are recommended for the red-legged frog to determine whether it is still present.

Western pond turtles were observed in Lake Merced in 1976 (Personal communication, Mr. Ed Ely). The western pond turtle is a federal candidate for listing and a state species of special concern. USFWS has been petitioned to list the western pond turtle as threatened or endangered depending on its range. The permanent waters and marsh vegetation provide suitable western pond turtle habitat.

Bullfrogs and fish prey on hatchling turtles and could reduce population sizes. Western pond turtles also require adjacent upland habitat for nest sites. Surveys are recommended for the western pond turtle to determine whether it is still present.

Several invertebrate candidate species for listing are known from or have potential to occur at Lake Merced, including the San Francisco forktail damselfly (one recorded from the 1970s), Leach's skyline diving beetle, and possibly the Ricksecker water scavenger beetle (Personal communication, Mr. John Hafernik). The San Francisco tree lupine moth, which has been recorded from Lake Merced, was dropped from the federal candidate list because it is more widespread than previously thought.

The San Francisco Chapter of the California Native Plant Society (CNPS) has stated that there are no rare or endangered plants known from Lake Merced (Personal communication, Mr. Jake Sigg). There are, however, four species that although common in other areas are considered rare by the San Francisco CNPS chapter including the Viscid tule, sandbar willow, Phragmites Communis (reed sps.), and wax myrtle (Personal communication, Mr. Jake Sigg). All of the species are associated with wetlands.

3.3.3 Water Level Criteria

The general relationship between lake level and habitat value for various fish, wildlife, and vegetation types are shown in Figures 3-5 through 3-7 for South, North, and Impound lakes, respectively. Species are grouped if they share similar habitat needs. Habitat value is indicated together on a qualitative scale ranging from "poor" to "excellent" and takes into consideration the quantity and quality of habitat. In terms of quantity, higher lake levels and greater lake volume result in more total habitat and thus larger populations for many species. Habitat quality may decline with higher lake levels for some species, however. For example, shallow water areas suitable for tules or warmwater fish spawning are most abundant at low lake levels.

The ranking of habitat quality was based on a comparison of conditions that would occur at a given lake level with optimal conditions for each species. Other factors considered included 1) the coastal fog and cool onshore breezes that result in water temperatures lower than optimal for growth of warmwater fish, regardless of lake level; and 2) the abundance of algae that makes the habitat less than excellent for trout even at high lake levels. Although conditions for tules and warmwater fish are probably only "fair" at high lake levels, those species would continue to survive and reproduce.

The relationships between lake level and habitat value were estimated principally by considering the water depth, total lake area, and bank steepness associated with various lake levels. These characteristics have been previously mapped and tabulated (Entrix, 1987). An indirect measure of average bank steepness at various lake levels is indicated on Figures 3-5 through 3-7. The number shown is not the actual ground slope, but the feet of lake level rise per acre of increase in surface area. These graphs show that banks generally are steeper at high lake levels.

FISHERIES

Fish Productivity. Lake levels, surface areas, and water level fluctuations, can have significant effects on fish productivity, especially for warmwater species. For all fish species, higher lake levels and smaller water-level fluctuations generally result in larger fish populations and greater fish productivity because of greater total lake volume and surface area. Falling lake levels have the effect of increasing fish densities and stress on individuals by reducing habitat availability and increasing competition for food. In addition, falling lake levels during the spawning season for resident warmwater fishes can reduce access to protective cover in shoreline vegetation, dewater fish nests, or expose nests to wave action. Adults may also desert nests, leaving eggs and juveniles exposed to predation.

Low but stable lake levels would likely improve conditions for warmwater species, such as catfish and bass, because of increased availability of optimal spawning habitat. It is assumed that spawning habitat is not needed for trout, which are imported from hatcheries.

Figures 3-5 through 3-7 show that fair to good conditions for warmwater fish can be maintained at lake levels between approximately 3 feet and 28 feet in South Lake, 9 and 30 feet in North Lake, and 13 and 30 feet in Impound lake. Figure 3-5 through 3-7 show that fair to good conditions for trout can be maintained at lake levels above 6 feet in South Lake, above 16 feet in North Lake, and above 25 feet in Impound Lake.

Predation by Piscivorous Birds. Several species of piscivorous (fish-eating) birds, including egrets, cormorants, grebes, and brown pelicans, occur at Lake Merced. Little or no information exists that quantifies the amount of fish these birds consume or the effect predation has on the gamefish populations. Predation by cormorants on planted rainbow trout is likely, however, because they have reportedly been observed to congregate in large numbers and display feeding behavior (diving) at fish planting locations during and after fish planting operations (Personal communication, Mr. Chris Senti). It has been estimated that 250 to 300 cormorants visit on Lake Merced during late fall (Personal communication, Mr. Chris Senti).

Water surface elevations may affect the feeding success rate of surface diving birds (such as grebes and cormorants) by increasing the amount of physical space fish have in which to escape. However, because cormorants can readily dive to 25 feet in search of prey, minimal change in the feeding efficiency of these birds would be expected to occur with varying lake levels. Likewise, the feeding efficiency of aerial diving birds (e.g., brown pelicans, kingfishers) and wading birds (e.g., egrets, herons) would not be expected to change with varying lake levels because these birds prey on fish near the surface.

VEGETATION AND WILDLIFE

Tules grow only in water less than about 3 feet deep. Because the lakes have fairly flat bottoms, the total area of water in that depth range reaches a maximum when lake levels are quite low. Low water levels enhance the freshwater marsh tule habitat, which is important to many species, including songbirds, bank swallows, red-legged frogs, and western pond turtles (See Photo 14). Although increased water levels would increase the length of shoreline, the steeper banks at high lake levels might partially offset this effect by decreasing the width of the shallow-water zone. This could reduce the amount of nesting habitat for songbirds, including nest sites of the saltmarsh yellowthroat. Loss of freshwater marsh habitat could reduce cover and basking sites for western pond turtles and California red-legged frogs (if present).

In addition to benefits to wildlife, tules trap sediment, stabilize banks, and act as a buffer from wave action to reduce bank undercutting. However, some habitat will be available even at high lake levels, and shallow water species would continue to be present. Figure 3-5 through 3-7 show that fair to good conditions for tules and marsh habitat can be maintained at lake levels between approximately 2 and 25 feet in South Lake, 7 and 26 feet in North Lake and 9 and 30 feet in Impound Lake.

Increased water levels could reduce the amount of shallow water habitat used by wading birds, dabbling ducks and shorebirds. Wading birds and dabbling ducks forage in water from a few inches to about 2 feet while shorebirds typically forage in shallower water and mudflats. Figures 3-5 through 3-7 indicate that fair to good conditions for diving ducks and birds can be maintained at lake levels above approximately 3 feet in South Lake, 9 feet in North Lake and 15 feet in Impound Lake.

Figures 3-5 through 3-7 show that fair to good conditions for turtles, frogs and dabbling ducks are very similar to that of warmwater fish, particularly in South and North Lakes. In Impound Lake, fair to good conditions can be maintained at lake levels above approximately 10 feet.

3.3.4 Water Quality Criteria

FISHERIES

Water quality may have a greater effect on the predation rate of fish-eating birds on gamefish than water level. High turbidity levels resulting from plankton blooms or suspended particulate matter may reduce the feeding success of fish-eating birds that rely on sight to locate fish.

Water temperatures in summer might become warmer at low lake levels, but the difference would probably be slight. Lake temperatures generally are cool and in a range more suited for trout than warmwater fish species. Cool water temperatures result from fog, wind, and cool air temperatures.

Surface water temperatures at two locations measured for this study on September 19, 1992 ranged from 64 to 66 degrees Fahrenheit. Air temperature was 59 degrees Fahrenheit. Water temperatures measured on February 13 and March 13, 1984 were 55 and 61 degrees Fahrenheit, respectively (Kennedy/Jenks, 1984). Mid-summer temperatures reportedly range as high as 68 to 71 degrees Fahrenheit (Personal communication, Mr. Chris Senti). Variations in lake temperature probably do not extend much beyond the range indicated by these data. Rainbow trout require cool (55-70 degrees Fahrenheit), clean water and dissolved oxygen concentrations near saturation for optimal survival and growth, whereas warmwater species such as largemouth bass require temperatures of 68 to 88 degrees Fahrenheit for optimal growth and can tolerate decreases in dissolved oxygen (Moyle, 1976). Thus, naturally occurring water temperatures are better for trout than for warmwater species.

Because conditions are frequently windy and water depth is fairly shallow, the water in Lake Merced is probably well-mixed most of the time. Dissolved oxygen profiles measured at two locations near the middle and northeast shore of South Lake on September 19, 1992, showed a small, gradual decrease in dissolved oxygen concentration from 8.5 to 8.7 mg/l at the surface to 7.2 to 7.6 mg/l at the bottom (water depths were about 15 feet). These concentrations are near saturation and indicate that the lake was not stratified into a warm, oxygen-rich surface layer and an underlying, cool, oxygen-depleted layer. At a third location, near the southwest corner of the lake, dissolved oxygen concentrations were lower and slight stratification might have been present at a depth of about 3 feet. Dissolved oxygen concentrations were 7.0 to 8.0 mg/l in the top 3 feet and 4.8 to 5.8 mg/l at greater depths (total depth was 12 feet). These lower concentrations are tolerable but undesirable for adult rainbow trout. The Basin Plan stipulates a minimum of 7.0 mg/l for coldwater habitat and 5.0 mg/l for warmwater fish (See Appendix H).

Effects of Algae and Aquatic Plant Control. Fish that have resided in Lake Merced for very long reportedly have a musty taste (Personal communication, Mr. Chris Senti). Algae are a common cause of off-flavors in fish, and the flavor varies with the type and amount of algae present. Other possible causes of off-flavors include decaying vegetation and agricultural chemicals. All of these possible causes are present at Lake Merced and could contribute to the off-flavors.

The use of algicides, such as copper sulfate, to control algae could result in adverse effects to fish populations. While concentrations of copper sulfate required to effectively control algae may not have direct effects on fish species, indirect effects to fish may occur. Algicides are toxic to a large number of invertebrates, which are important to fish as food (Boyd, 1979). In addition, the decomposition of algae killed following copper sulfate applications may lower or even deplete dissolved oxygen in the lake (Boyd, 1979). Although single applications of algicides may not have any adverse effects on fish species, algicides could result in undesirable effects on fish species from chronic exposure. Toxicity to fish species is variable and is dependent on several factors, including water temperature, water quality, exposure time, and species. For example, trout are adversely affected by copper sulfate in concentrations 15 times smaller than those that adversely affect largemouth bass (Boyd, 1979).

The reduction of algae may also increase growth of undesirable rooted aquatic plants because light penetration may increase as a result of increased water clarity. Furthermore, improved water clarity may allow sight-feeding fish predators, such as grebes and cormorants, to prey more easily on fish.

VEGETATION AND WILDLIFE

Existing water quality in Lake Merced is generally adequate for the vegetation and wildlife species that occur or could occur at the lake.

3.4 IMPACTS OF BENEFICIAL USES ON EACH OTHER

Water level and water quality requirements for the general beneficial use categories are sometimes in conflict, even between various sub-uses within these beneficial uses. Table 3-2 and Figure 3-8 provide a summary of the impacts of existing conditions on beneficial uses and of their minimum and maximum lake level requirements on each other.

3.4.1 Impacts of Emergency Water Use on Other Beneficial Uses

RECREATION

Management of the lake for emergency water use implies maintaining lake levels to its highest capacity at approximately 30 feet. Most recreational uses (fishing and boating) require a lower lake level at approximately 26 feet. Maintaining the lake level at 26 feet, rather than 30 feet, is not anticipated to have a large effect on emergency water supply availability. Because Lake Merced is hydraulically connected to the regional aquifer, inflow to the lake would be substantial during pumping, and the amount of water available for emergency water use would be significantly higher than the actual volume of the lake (See Section 6 for further discussion). Therefore, limiting the lake level to 26 feet should not be a large impact the overall amount of emergency water available.

Other "low lake level" recreational uses, such as bird watching and walking along currently exposed shorelines, would be impacted by management of the lake for emergency water supply. However, it is anticipated that these activities could still continue, but in a somewhat lesser capacity with higher lake levels.

The minimum water level for emergency water use would be approximately 9 feet based on the elevation of the lower intake drums. This level is substantially lower than the existing water level. If the lake was allowed to drop to this level, the result would be an adverse impact on most recreational uses such as fishing, boating, and general aesthetics because most existing facilities such as fishing piers, boat docks and ramps would not be usable.

Water quality impacts of managing the lake for emergency water use would generally improve water quality conditions for recreation. Higher lake levels are anticipated to reduce coliform bacteria and algae levels which should improve aesthetic qualities of the lake including color, odor and amount of floating material. In the event that copper sulfate treatment is performed, algae content would be further reduced.

Currently, certain controls on recreation are instituted by the PUC Resolution in order to protect Lake Merced for potential potable use. Fishing is only allowed from designated shore areas and from boats, and no gasoline motors are allowed to reduce pollutants from entering the water. Swimming is also prohibited to reduce human contact with the lake. Windsurfing is allowed on the lake, however, skin contact with the water as a result of windsurfing is minimal. It is anticipated that these controls would continue to be implemented in order to maintain the lake as an acceptable source of emergency water supply.

FISH AND WILDLIFE

Standby Conditions: High Water Levels. To maintain Lake Merced in a state of preparedness as an emergency supply of potable water, it would be desirable to maintain a high lake level at (about 30 feet). The graphs showing the qualitative relationships between water levels and wildlife habitats (Figures 3-5 through 3-7) indicate that an increase from the August, 1992 lake level (17.67 feet) to the preferred standby level, would probably not substantially affect the amount of tule vegetation or wildlife species that use tules. Total fish populations probably would increase, although there may be a greater increase in trout populations than warm-water fish populations. Steeper shoreline slopes at high lake levels might decrease the amount of shallow water and wetland habitat along the shoreline.

The rate at which the lake level is raised from the present level to the preferred standby level should be slow enough to allow tules and willows to reestablish further upslope. In areas with a gradual slope (5:1 to 10:1) bands of wetland vegetation would probably move upslope with tules at the deeper (4 to 6 feet) levels followed by willows. Upland tree and shrub species that have become established close to the shoreline during the recent years of low lake levels would probably die when lake levels are raised.

Emergency Conditions: Rapid Water Level Declines. During an emergency, the lake level in Lake Merced would be drawn down by pumping. The maximum rate of water level decline would probably not exceed 2 inches per day, and total drawdown after 84 days would be at most about 7 feet (See Section 6). Water levels could not be drawn down below approximately 9 feet, which is the centerline elevation of the lower intake drum. This rate of water level decline would not be expected to cause significant impacts to wildlife species or their habitats because even at a lake level of 9 feet, there would still be substantial amounts of open water and tule vegetation. There may, however, be a significant loss of tule vegetation if decline of more than 3 feet persist for more than several weeks.

Because emergency use would occur very rarely, it would be reasonable to mitigate for any adverse effects on vegetation by replanting or restoration following the emergency.

3.4.2 Impact of Recreational Uses on Other Beneficial Uses

EMERGENCY WATER SUPPLY

In general, recreational uses tend to lower water quality in the lake which lessens its desirability as an emergency water supply. Although recreational uses are stipulated as non-water contact, it is inevitable that heavy use around the lake would increase coliform bacteria levels, as well as the amount of floating material and associated off-colors and odors.

Golfing may indirectly contribute chemicals to the lake which could lessen its desirability as an emergency water supply. Fertilizers, pesticides and herbicides are used at HPMGC. Fertilizers could be contributing nitrates to the lake, thereby increasing algae and associated turbidity levels. As pesticides and herbicides are not currently monitored at Lake Merced, it is not known whether these chemicals impact water quality.

Impacts from the shooting clubs are expected to be minimal in regard to emergency water use. In water, lead is most soluble under conditions of low pH, low alkalinity, low organic content, low concentrations of suspended sediment, and low concentrations of the salts of calcium, iron, manganese, zinc, and cadmium. These conditions are the opposite of conditions in Lake Merced (Kennedy/Jenks, 1984; Hem, 1985). Therefore, the solubility of lead in Lake Merced is anticipated to be low.

Low lead solubility is supported by measurements made of lead concentrations in lake waters. In 1989, 1990, and 1991, lead in lake water samples was measured at 0.003 mg/l, <0.001 mg/l, and <0.001 mg/l, respectively (See Appendix C). Therefore, lead concentrations are measured below the Drinking Water Standard for lead of 0.05 mg/l.

FISH AND WILDLIFE

Recommended water levels for recreational activities range from 21 to 26 feet for fishing and boating, and to 27 feet for golfing. These levels are not expected to substantially change the habitat or wildlife species composition at Lake Merced. Trout may be favored over warmwater species at these lake levels.

Impacts from Human Disturbance. Higher water levels would increase the recreational opportunities which could increase the number of anglers, boaters, and picnickers. Based on its urban setting and the historical recreational use at Lake Merced, no additional impacts are expected from disturbance to wildlife around the lake. Due to Lake Merced's historical use as a recreational facility, it is probable that wildlife has adapted to its urban surroundings; however the adoption of a plan to reduce the number of feral cats which prey on small mammals, birds, and reptiles, may be beneficial.

Potential for Bioaccumulation of Lead. An estimated 27 tons of lead shot is deposited annually into South Lake (Crosby & Overton, 1990). In 1989 and 1990, concentrations of lead in sediments and soils collected from the Pacific Rod and Gun Club ranged from 10 to 46,000 parts per million (ppm) in soils, 0 to 14,000 ppm in lake sediments (Crosby & Overton, 1990).

A study conducted by Ecology and Environment (E&E) in 1993 included the sampling and analysis of soils, sediments, plants, and benthic (bottom-dwelling) invertebrates. The study did not include sampling and analysis of fish. Investigation of lead distribution in soils and sediments was conducted by sampling within a 100-foot-by-100-foot grid system. The geometric mean of surface soil and sediment samples was 265 ppm and 143 ppm, respectively. Maximum soil and sediment concentrations at the surface layer were 19,000 ppm and 1,200 ppm, respectively. Background surface soil and sediment sample geometric mean was 27.7 ppm and 38.9 ppm, respectively. The highest concentrations of lead was found in the central area and at the northwest end of the gun club. Lead in biota was greatest in aquatic plants. A maximum concentration of

222 ppm was found in coontail, a submerged weed. Lead was also elevated in benthic invertebrates at 52.8 ppm in snails attached to the coontail.

E&E conducted an ecological risk assessment to evaluate the potential risks of lead to benthic invertebrates, aquatic plants, soil invertebrates, terrestrial plants, and waterfowl. Although lead occurs above background levels in benthic invertebrates and vegetation, there did not appear to be any substantial effects of lead on these species during this survey. The ecological impacts of lead which could potentially affect beneficial uses (fish and wildlife habitat maintenance) are considered to be minimal or low for benthic invertebrates, aquatic plants, soil invertebrates, terrestrial plants, and waterfowl through the food chain. However, waterfowl ingestion of lead shot could be a significant impact based on reasonable maximum and typical exposure estimates, and toxicity estimates from published sources.

Because of their feeding habits, diving ducks are susceptible to picking up lead shot. The birds strain mud through their beaks to obtain food and could ingest shot in the process, mistaking them for bits of sand or food. Lead shot retained in the gizzard gradually dissolves and spreads throughout the body, producing weakened birds that may starve or fall prey to predators. Reproductive success is also decreased. In many species, the ingestion of a single shot is often fatal. Species such as mallards and pintails that feed in shallow water by sifting through bottom mud are more likely to encounter shot than are species that feed on submerged vegetation or at the surface. In the dry season, species that probe for food deep in the sediment are especially susceptible. Lead-poisoned waterfowl may in turn be eaten by predators and result in secondary poisoning, especially in raptors such as hawks. Birds at Lake Merced have not been tested for lead content or symptoms of lead toxicity.

Effects on fish cannot be evaluated at Lake Merced because the detection limit, 0.5 mg/l, is well above the 1 to 5 micrograms/liter (ug/l) concentration at which adverse effects have been reported in aquatic biota (Eisler, 1988). Fish in Lake Merced have not been tested for lead content, so implications for human consumption are unknown. To address effects of lead on aquatic biota, lake waters in the vicinity of the Pacific Rod and Gun Club should be tested for lead using a lower laboratory detection limit.

E&E recommended that lead levels be monitored in plants and invertebrates to determine if mitigation will be needed in the future; or, a periodic lead shot recovery program could be instituted. Waterfowl monitoring should be conducted to verify the current level of predicted risks. In the event that recreational users, particularly young children, are allowed direct contact with soils, a human health evaluation for the site should be conducted or access should be restricted.

EFFECTS FROM GOLF COURSES

Pesticides, herbicides, and fertilizers used at HPMGC may be entering Lake Merced by direct surface runoff. Some gullying and soil erosion are visibly evident along the steep embankment between the golf course and South Lake, suggesting that surface runoff from the golf course sometimes occurs. SFWD water quality data for Lake Merced do not include analyses for agricultural chemicals. One water sample collected at location B-1, near the Lake Merced Sewage Pump Station on John Muir Drive, did not show pesticides above laboratory detection limits (See Appendix C). A study conducted in 1990 by MFG indicate that the fertilizer and pesticide application program at the HPMGC is well managed. However, to determine potential impacts from these chemicals, groundwater samples should be analyzed for nitrate and lake waters should be analyzed for pesticides.

3.5 IMPACTS OF STORMWATER INFLOW INTO THE LAKE

3.5.1 Impacts on Emergency Water Supply and Recreation

As described in Section 2.2, the Vista Grande stormwater sampling study conducted by Kennedy/Jenks revealed that total coliform, turbidity, suspended sediments, copper and zinc concentrations are higher than in lake waters. Other stormwater constituents were measured to be very similar to Lake Merced water or lower (See Appendix E). Based on the volume of stormwater contributions estimated in Section 2.2, it is not anticipated that the quality of excess Vista Grande stormwater has a significant impact on the overall water quality of North and South Lakes. Additionally, any increases in coliform bacteria content from excess Vista Grande stormwater would be treated using disinfection prior to distribution for emergency water supply.

For Impound Lake, the volume increase from overflow is estimated at 241 percent during a 25-year storm event. Approximately half of that increase may be expected for a 5-year storm. Unless Impound Lake levels are initially high, and excess stormwater flows into South Lake through the existing causeway, the quality of water could be degraded in Impound Lake from excess stormwater during 5-year and greater storm events.

Non-contact water recreation at Impound Lake primarily includes fishing in limited areas and bird watching. It is anticipated that some Basin Plan objectives for inland surface water bodies, such as suspended materials and turbidity are exceeded during 5-year and greater storm events.

A water quality testing program for testing both Vista Grande stormwater and Lake Merced water was designed by SFWD in January, 1993, in order to evaluate potential impacts of stormwater on lake quality (See Appendix E). The constituents to be tested include extractable organics (acids and base neutrals), priority metals, oil and grease, pH, total suspended solids, conductivity, TOC, and turbidity. This study recommends that total and fecal coliform and nitrogen be added to the sampling suite. These monitoring data may be used to further evaluate impacts of stormwater on Lake Merced and the potential for increasing stormwater inflows to the lake for the purpose of raising lake levels.

3.5.2 Impacts on Fish and Wildlife

To evaluate the toxicity of Vista Grande stormwater, a bioassay study was done in which rainbow trout were placed in tanks containing various proportions of Vista Grande stormwater runoff. After four days, all of the fish were still alive, including the ones in undiluted stormwater runoff (Kennedy/Jenks, 1984). These data indicate that the quantity and quality of stormwater runoff entering Lake Merced do not pose a health risk to fish and wildlife.

Although the bioassay results indicate that stormwater runoff does not pose an acute toxicity hazard to aquatic organisms, the results are not adequate to rule out the possibility of chronic toxicity or bioaccumulation associated with metals, pesticides or other trace organic compounds.

Shoreline and upland vegetation such as tules and willows would probably not be affected by short-term rises in lake level from stormwater because the maximum rise is expected to be only a few inches.

3.6 POTENTIAL FUTURE BENEFICIAL USES

The most likely potential future beneficial use of Lake Merced that is consistent with existing beneficial uses is as a location of artificial groundwater recharge.

Further in this study, water resource alternatives are presented that are intended to raise the long-term average lake level, the purpose of which is to enhance existing beneficial uses of the lake. Artificially raising lake levels will necessarily recharge surrounding groundwater resources—and, in fact, could be viewed as an independent beneficial use of the lake. Because Lake Merced is an exposure of the groundwater, it could serve as a location from which to recharge groundwater for the purpose of raising lake levels, increasing flow to nearby wells, and preventing seawater intrusion. Conversely, pumping of Lake Merced for emergency use could potentially impact water levels in nearby wells, such as the San Francisco State University well. It should be noted that groundwater recharge, a recognized beneficial use identified by the RWQCB, has not been formally considered for Lake Merced.

As a source of groundwater recharge, the water resource alternative selected to raise lake levels should be evaluated as such. The RWQCB Basin Plan stipulates "the Best Available Technology (BAT) or Best Management Practices (BMP) for control of the discharge as necessary to assure the highest quality consistent with maximum benefit to the people of the State." The Basin Plan does not identify specific sources of acceptable recharge, however, and it is possible that sources of water such as reclaimed water or stormwater may be considered an acceptable "conjunctive use" under controlled conditions.

A general discussion of potential water quality impacts of the water resource alternatives presented in this study is included in Section 7. More detailed evaluations would be expected during the water resource alternative development and evaluation phase described in Section 8 and during the Environmental Impact Review process that should accompany the selection of an alternative resource to raise lake levels.

Section 4

RECOMMENDED PRELIMINARY LAKE LEVEL AND QUALITY CRITERIA, MONITORING PROGRAM AND MITIGATIONS

4.1 RECOMMENDED LAKE LEVEL CRITERIA

A preliminary lake level to satisfy most lake uses is suggested at 26 feet. This lake level would be ideal for most recreational uses (fishing and boating), should not substantially effect wetland habitat and associated wildlife, would improve conditions for trout, and could lessen algae somewhat by increasing the lake volume. The volume of emergency water supply would be slightly less than if the lakes were filled to full capacity. However, the lake's hydraulic connection with the encompassing aquifer would allow groundwater inflow into the lake which would be available for emergency pumping.

Raising water levels from the current level to 26 feet should be done slowly in order to allow for re-establishment of wetland habitat further upslope. Lowering water levels for the use of emergency water would not cause significant impacts to fish and wildlife, although a loss of wetland habitat could occur.

Based on the estimated rate of lake level decline during emergency pumping, it is possible that the lake could still be used for recreational purposes during an emergency, if desired.

4.2 RECOMMENDED LAKE QUALITY CRITERIA

The quality of the lake appears to be generally acceptable as a "second choice" emergency water supply although its desirability could be raised by reducing total coliform and turbidity levels. Lake water would not be considered potable without a filtration system as well as a disinfection system.

The quality of the lake as both a water-contact and non-contact recreational facility does not currently meet some RWQCB Basin Plan standards for inland surface water bodies. These standards generally pertain to color, tastes and odors, floating material, sediment, turbidity, and potentially, fecal coliform. Therefore, these parameters should be improved such that they do not affect the recreational activities designated by the Basin Plan as beneficial uses.

The quality of the lake in regard to fish and wildlife habitat is generally suitable with the exception of dissolved oxygen which has been reportedly low for both warmwater and coldwater fish. The dissolved oxygen content could probably be raised somewhat by raising lake levels.

4.3 WATER QUALITY MONITORING REQUIREMENTS

An effective monitoring program for water quality should be based on the quality requirements of all of Lake Merced's beneficial uses and the likely variability of the lake water quality. As Lake Merced is a surface water body, the "Objectives for Inland Surface Waters" are applicable to Lake Merced (RWQCB, 1986).

Water quality requirements for beneficial uses at Lake Merced, specifically in context as a surface water body, were discussed in Section 3. In general, wildlife and fresh-water aquatic habitat are impacted by alkalinity, dissolved oxygen, pH, floatables, settleable solids, TDS, temperature, turbidity, transparency, and an array of inorganic and organic parameters. There is no general requirement for total coliform.

The primary recreational use at the lake is non-contact. Water quality parameters for non-contact recreational use focus on coliform bacteria, floatables, oil and grease, color, odor, pH, and temperature.

Lake Merced as a potential municipal water supply must be evaluated in terms of DOHS requirements for potable drinking water supplies. As discussed in Section 2.3, based on the Surface Water Treatment Rule, Lake Merced would not be considered potable with only disinfection (chlorination). Thus, Lake Merced is relegated as an emergency water supply and accompanying water quality standards are reflected in the DOHS Disaster Response Plan rating of alternate water sources.

4.3.1 Current Lake Quality Monitoring

The SFWD currently monitors North and South Lakes monthly for basic water chemistry including pH, alkalinity, chloride, hardness, turbidity, color, conductivity, and total coliform. Since 1989, lake waters have also been tested annually for a variety of minerals including metals, chloride, sulfate, phosphate, nitrate, TDS, and dissolved oxygen. Monthly test results are listed in Table 2-1. Annual test results are included in Appendix C.

4.3.2 Recommended Modifications to Lake Quality Monitoring

The current Lake Merced water quality monitoring program includes most of the parameters of concern for the lake's beneficial uses. However, additional parameters, including chloropyll-A, temperature, taste and odor compounds, fecal coliform, pesticides, total organic carbon, and oil and grease, should be added. Monitoring parameters to address Lake Merced beneficial uses are listed in Table 4-1.

To determine whether fertilizers are impacting Lake Merced, shallow groundwater wells should be installed near the edge of the lake. If this recommendation is carried through, upgradient wells should also be installed near Lake Merced Boulevard to measure background nitrogen levels in groundwater. The potential for surface water runoff from the golf courses should be directly observed during a rainstorm of above-average intensity, and during average irrigation of the golf courses. Runoff conditions in the vicinity of the marsh near the 18th tee at the HPMGC should be carefully observed.

4.4 PROPOSED MITIGATIONS

In order to achieve the lake level and quality criteria described above, the following mitigations are recommended:

- Increase lake levels slowly to approximately 26 feet in order to 1) increase the amount of water available for emergency water supply, 2) to improve access to piers and docks, 3) to improve water quality in accordance with Basin Plan objectives. Select a method of lake level restoration that will be compatible with lake quality criteria;
- Increase the number of restroom facilities; these facilities should be located near fishing piers and other heavy use areas to possibly lower total coliform concentrations in the lake.
- Treat overflow from the Vista Grande culvert that enters Lake Merced for turbidity and suspended solids. This may also reduce the total coliform concentrations entering the lake.

- Short term impacts of emergency water use could be mitigated by re-stocking fish populations and re-establishing tules after the emergency has passed.

- Direct runoff of agricultural chemicals from the golf course could be minimized by the following management practices:

  Avoid application of chemicals during the winter rainy season (which, according to Del Carlo, is a practice already instituted by the gardeners);

  Reduce the amount of irrigation return-flow using either empirical methods to determine evapotrans piration demand or in-situ probes to measure moisture.

  Adjust sprinkler nozzles so that irrigation rates are slow enough to avoid surface runoff;

  Construct a low berm along the edge of the shoreline bluff to detain surface runoff and prevent it from flowing into the lake; and

  Avoid use of agricultural chemicals in areas near the lakeshore.

  Periodically review alternatives to the chemicals used to ensure use of the least toxic, least persistent, least mobile. Timed-release fertilizers are an alternative that will decrease the potential for elevated nitrate concentrations to be transported to Lake Merced.

- Modify existing water quality monitoring program as described in Section 4.3;

Other actions/mitigations not specifically related to the improvement of lake quality would include:

- Review March 1993 study on lead characterization at the Pacific Rod and Gun Club; implement plan to monitor plants, invertebrates and waterfowl for lead; or reduce lead concentrations by dredging;

- Create an Emergency Operations Plan to use Lake Merced for emergency water supply; this Plan should address 1) fuel requirements in order to run generators, 2) disinfection, and 3) potential copper sulfate treatment.

- Although RWQCB total coliform standards for water-contact recreation sports are generally met, the levels included in Table 2-1 should be reviewed by the SFDPH and other City agencies to develop a policy regarding potential health hazards of water-contact sports.

- Conduct surveys to determine the presence of red-legged frog and western pond turtles at Lake Merced.

- Determine loss of marsh vegetation from raising lake levels by comparing the area of land occupied by marsh vegetation currently and predicted land coverage at higher lake levels.

Section 5

BENEFICIAL USE PRIORITIES AND POTENTIAL CONFLICTS

The purpose of this Section is to prioritize the beneficial uses of Lake Merced described in Section 3 of this report and to summarize potential conflicts between the various beneficial uses and recommended management strategies. Potential conflicts are delineated in a matrix format in Table 3-2. The matrix summarizes the various beneficial uses of Lake Merced, the applicable water quality standards, the current status of the lake with regard to those standards, the preferred management strategy for each beneficial use and potential conflicts between the various lake uses and lake management strategies.

Additionally, this Section includes comments received at a public information meeting held April 26, 1993, and sets forth the steps necessary to resolve current and future conflicts between the different beneficial uses at the lake.

5.1 PRIORITIZATION OF BENEFICIAL USES

The following Section prioritizes the beneficial uses of Lake Merced in recommended order based on our findings throughout the course of this study and within the existing legal framework.

5.1.1 Emergency Water Supply

The use of Lake Merced as a source of emergency water supply is recommended as the first priority of management of the lake. SFWD and SFFD personnel indicate that water supplies within San Francisco (inclusive of drinking water reservoirs and firefighting reservoirs) would last approximately four days if water distribution from outside sources were cut off (Personal communication, Mr. Joe Pelayo and Mr. Dan Barden). In eastern San Francisco it is likely that Bay water would be used for firefighting. In western San Francisco, the infrastructure does not exist to use seawater for firefighting. Therefore, unless broken lines, etc., could be repaired during that time, Lake Merced would be the only significant local source of emergency water which is currently on line in western San Francisco to provide emergency water supply for firefighting. Unless another local water source is put on line, emergency water supply use should be considered the most important priority for Lake Merced.

Lake Merced water could be used for fire fighting in three ways:

- Pumped into the Sunset and Sutro Reservoirs from the Lake Merced Pump Station;
- Directly from the lake using suction pumps;
- Pumped into cisterns using relay pumping system;

Lake Merced water could also be used as emergency supply for other non-potable uses, such as sanitary controls.

5.1.2 Threatened and Special Status Species

The second most important management strategy for Lake Merced is management of the Lake to meet applicable laws that protect threatened and special status plant and animal species.

The state and federal endangered species acts (Federal Endangered Species Act, 1973 and California Fish & Game Code, amended sections 2072 to 2093) could limit lake management if it resulted in a "taking" of individuals of that species. Of the sixteen special-status species of plants and wildlife at Lake Merced, only the bank swallow is listed as threatened. It is illegal to "take" threatened or endangered species. An act of taking generally includes actions that directly result in mortality. Because the bank swallows only use Lake Merced as a source of insects for food, management of the lake is unlikely to directly cause mortality unless the lake is allowed to go completely dry.

The other special status species are candidates for listing or are designated as species of special concern by the DFG. These species have no direct legal protection, but are indirectly protected by CEQA. Typically, actions which might adversely affect these species come to the attention of wildlife management agencies through the CEQA process. The agencies often recommend mitigation measures that will protect wildlife. Depending on what actions are proposed, an EIR may be necessary to implement a management plan for Lake Merced. Special status species of concern at Lake Merced are generally related to tule and marsh habitat. Section 3.3 points to the probability that "low water" habitats can probably be maintained even if lake levels are raised.

5.1.3 Recreation

Lake Merced is well known throughout the Bay Area as a recreational center providing a wide variety of uses including fishing, boating, picnicking, windsurfing, and golfing. Therefore, the third priority management strategy for Lake Merced is management of the lake for recreational uses, with restrictions set forth in the PUC Resolution.

As described in Section 2.1, the PUC Resolution states that "the Lake Merced Tract can be used both for water supply and park and recreational purposes, and that such use can best be developed and administered by the Park and Recreation Commission". However, the SFWD is ultimately responsible for the quality of the water in Lake Merced as well as the maintenance of the lake and all underlying lands (Personal communication, Mr. Joshua Milstein).

5.1.4 Habitat for Non-Special Status Fish and Wildlife

Lake Merced is currently a habitat for a large variety of fish and wildlife described in detail in Section 3.3. Therefore, the fourth priority management strategy for Lake Merced is to manage the lake to provide suitable habitat for non-special status fish (other than those species directly related to recreational fishing activities) and wildlife.

5.2 POTENTIAL CONFLICTS

Table 3-2 is provided as a tool to identify potential conflicts between various uses and lake management strategies. This table is organized as follows:

Column 1: Identifies the major beneficial uses of Lake Merced including emergency water supply, fish and wildlife habitat and recreation.

Column 2: Identifies the specific categories within each of the major beneficial uses identified in Column 1. These specific categories correspond to the beneficial uses discussed in Chapter 3.

Column 3: Identifies the applicable water quality standards pertaining to the specific categories.

Column 4: Summarizes the current status of Lake Merced based on water quality data and the information obtained during field visits and data gathering for this study. Only those water quality standards that are not being met are identified.

Column 5: Identifies the preferred management strategy for each of the specific uses identified in Column 2. This column identifies how the current management or water quality aspects of Lake Merced should be changed for the particular use. In most cases, this would involve correcting the item identified in Column 4 along with other specific changes.

Column 6: Identifies conflicts between the preferred management strategies for each specific use.

Examination of Table 3-2 indicates that some conflicts occur between beneficial uses and DOHS and RWQCB water quality criteria; however, relatively minimal conflicts occur between the various beneficial uses themselves. Conflicts identified include:

- Recreation and fish and wildlife beneficial uses and a variety of RWQCB water quality standards;
- Emergency water supply, most recreational activities, and "high water" fish and wildlife habitats with optimum conditions for tule/marsh and warmwater fish habitat ("low water" habitats), although it appears that acceptable conditions could still be maintained at high water levels;
- Use of Lake Merced as a "first choice" emergency water supply because of turbidity levels and the potential formation of excessive THMs after chlorination.

5.3 LAKE MANAGEMENT OBJECTIVES

- Management objectives for the lake should be to sustain the following beneficial uses:
- First or second choice emergency water supply;
- Non-contact recreation;

Fish and wildlife habitats (emphasis of "high water" fish and wildlife habitats, while maintaining acceptable conditions for "low water fish and wildlife habitats.

The objectives above may be attained by improving water quality, particularly coliform bacteria and turbidity levels, and increase water quantity. Potential actions which would attain the management objectives listed above are listed as mitigations in Section 4.4.

5.4 PUBLIC INVOLVEMENT

This study identifies potential conflicts between beneficial uses of Lake Merced based on available information and discussions with involved City agencies. To ascertain public concerns, a public information meeting was held on April 26, 1993, at the Recreation Center for the Handicapped in San Francisco, to present a summary of the Draft Lake Merced Water Resource Study findings. A list of public comments received at the public information meeting is included in Appendix J.

The following conflicts among beneficial uses at Lake Merced raised at the public information meeting but not addressed in this study include:

- Raising lake levels versus to recreational/fishing beaches at South Lake and Impound Lake.

- The desire to reestablish the connection between South Lake and Impound Lake versus access to recreational/fishing beaches.

- The impact of higher lake levels on wildlife nesting, as well as the rate and timing at which lake levels would be raised.

5.4.1 Conflict Resolution

Based on the evaluation of potential conflicts and the public comments received, the following steps should be taken to resolve additional conflicts identified during the public meeting:

- Additional technical analyses should be conducted to evaluate the conflicts listed above. The technical analyses should include:

  1) Determine physical features (elevation, square footage, etc.) of recreational/fishing beaches at South Lake and Impound Lake and evaluate the impact of raising the lake level.

  2) Determine necessary lake level to reconnect South Lake and Impound Lake. Other physical constraints to reconnecting the lakes should be investigated such as sediment build-up, hydraulics, etc. This information should be compared to the proposed lake level to determine if re-connection of the two lakes would occur. If re-connection would not occur with the proposed lake level, the necessary measures to reconnect the lakes should be identified.

  3) A wildlife specialist familiar with the habitat and species present at Lake Merced should review the proposed lake level recommendations and evaluate the potential impact on wildlife nesting. The rate and timing at which the lake level would increase should also be evaluated.

- Once the technical studies identified above have been completed, a supplemental report to the Lake Merced Water Resource Study should be prepared. The supple-mental report should document the findings of the technical studies. Because the studies would be conducted in response to public comments, their findings should be made available to the public or presented at a public information meeting. The purpose of this step would be to obtain input regarding the adequacy of the studies and to inform the public of any changes in lake level and water quality management strategy that may have arisen.

- Upon completion of the supplemental studies and obtaining public input, the SFWD could adopt a formal policy regarding the desired lake level and water quality.

Section 6

HYDROLOGY OF LAKE MERCED

This Section describes the development of a groundwater model used to explore the reasons for lake level decline and to estimate water quantities needed to raise lake levels. The groundwater model also provides estimates of emergency water supply availability from the lake.

6.1 BACKGROUND

An accurate evaluation of the water budget of Lake Merced and its connection with the surrounding groundwater system will indicate the effects of groundwater overdraft, droughts, and emergency use of the lake on lake levels. An understanding of lake hydrology is also necessary to identify feasible and effective measures for restoring and maintaining desired water levels in the lake.

Lake Merced is an exposure of the water table. There is currently no surface outlet from the lake, and surface inflow from stormwater runoff is small or infrequent. The lake is not stagnant, however, because substantial amounts of groundwater flow through it. Thus, the lake and groundwater system must be evaluated as parts of a single hydrologic system.

Kirker, Chapman and Associates and Todd (1972) documented increases in groundwater pumping between the late 1940s and 1971 and the resulting decline in groundwater levels in the Daly City-San Bruno area. By 1971, water levels in Daly City were over 100 feet below sea level. The study addressed the possibility that Lake Merced recharges the groundwater basin. Based on the mean inflow of groundwater into the lake, the study concluded that Lake Merced does not contribute to Daly City's groundwater supply.

Yates et al., (1990) estimated water budgets for Lake Merced and for the groundwater system in an area surrounding the lake. The budgets indicated that lake levels are declining as a gradual response to groundwater overdraft in deep aquifers beneath the lake; however, estimates of some components of the groundwater budget and of the amount of groundwater flowing through the lake were fairly uncertain. A simple modeling exercise of an aquifer test at the Oceanside Water Pollution Control Plant (OWPCP) site indicated that responses to changes in the hydrologic system could take decades to reach equilibrium.

Applied Consultants updated pumpage, recharge, and water level data for the Daly City-San Bruno area; developed a groundwater model of the area (Applied Consultants and C/REM, 1991); and divided the development of the groundwater basin into four periods: 1920-1949, 1950-1964, 1965-1981, and 1982-1988. Although Applied Consultants did not specifically address potential impacts to Lake Merced, it is apparent from groundwater contour maps that inflow to Daly City comes, in part, from the general area of Lake Merced.

6.2 GROUNDWATER MODEL

A groundwater model of the Lake Merced-Daly City area was developed for this study to answer questions specifically related to Lake Merced hydrology. Model design, assumptions, and data are briefly described in this section. A more complete documentation of the model is provided in Appendix K.

6.2.1 Model Boundaries

The model extends farther north and west than the Applied Consultants model and extends south only as far as the cemeteries on the south side of Daly City. The modeled area and the finite-difference model grid are shown in Figure 6-1. The grid contains 39 columns, 44 rows, and three layers. Grid spacing is non-uniform to enable more accurate simulation of areas with steep water level gradients in the vicinity of Lake Merced.

The locations of model boundaries were carefully selected to coincide with effective boundaries in the groundwater flow system. Areas of exposed bedrock occur on San Bruno Mountain, Mount Davidson, Twin Peaks, and subsidiary hills form the eastern edge of the modeled area. Small amounts of inflow from fractures in the bedrock are included as constant inflows to the active model cells adjacent to the bedrock areas.

The northern and southern boundaries of the modeled area follow flow lines in the groundwater system. These are effectively no-flow boundaries because groundwater does not cross flow lines. The southern boundary follows a line of symmetry that passes through the middle of a water level depression near the cemeteries. Groundwater in this area flows from the sides of the valley toward the center, and consequently, does not cross the model boundary. To maintain symmetrical water levels across the model boundary, only half the cemetery pumpage is included in the model.

The western boundary of the modeled area is located about 1.5 miles offshore to enable reasonable representation of the connection between the groundwater system and the ocean. Water can move in either direction between the ocean and the groundwater system over the entire offshore area of layer 1 (the uppermost layer) and along the westernmost column of cells in layers 2 and 3. The "leakiness" of the hydraulic connection with the ocean can be adjusted to improve model accuracy and to test the potential for seawater intrusion. The groundwater level at the ocean boundary cells is tied to sea level (adjusted with depth to account for the density difference between seawater and fresh water).

6.2.2 Aquifer Characteristics

A diagram of model layers and their hydraulic characteristics is shown in Figure 6-2. Model layer 1 represents the shallow aquifer, which consists of dune sand deposits and the Colma Formation. The base of layer 1 is at an elevation of -80 ft. MSL, which is the average top elevation of an extensive clay layer that occurs in the Lake Merced vicinity. Layer 1 is unconfined, and its upper surface is the water table. The horizontal hydraulic conductivity (Kh) of layer 1 is 18 feet per day (ft/d), and the specific yield (Sy) is 0.12. These values were estimated from available aquifer test results from nearby wells and modified slightly during model calibration. Lake Merced is represented as a group of model cells with a very high Kh (4,000 ft/d) and an Sy of 1.0. With these values, the flow and storage properties of the open body of water are correctly included within the shallow aquifer.

Model layer 2 represents the clay confining layer, with a typical thickness (b) of 50 feet. Flow through this layer is essentially vertical and governed by its leakance, which is the vertical hydraulic conductivity (Kv) divided by the layer thickness. A leakance of 0.0006 per day was obtained from model calibration and used throughout the layer. A storage coefficient (S) of 0.05 was obtained by calibration so that simulated long-term water level trends matched measured trends. Releases of water from storage in clay layers is very slow, often occurring over a period of years following a change in pumping stress in the overlying or underlying aquifer.

Model layer 3 represents the remainder of the groundwater basin extending down to bedrock or to slightly below the depths of typical deep wells, whichever is shallower. Bedrock surface elevations were obtained from the results of a detailed gravity survey (Phillips et al., 1992). This layer corresponds to the Merced Formation, which consists of fine sand deposits interlayered with occasional clay layers. Some of the layers, such as the one represented by model layer 2, are quite thick and form substantial barriers to groundwater flow. Because of this, parts of the basin below the deepest wells do not strongly interact with the shallower aquifer zones and can reasonably be omitted from the model. A hydraulic conductivity of 4 ft/d was used throughout layer 3 and was obtained by calibration.

6.2.3 Groundwater Recharge

Groundwater recharge in urban and suburban areas, which cover most of the modeled area, is primarily from deep percolation of rainfall, applied irrigation water, and leaky water and sewer/stormwater pipes. Recharge in these areas is greater than in undeveloped areas with natural vegetation, where rainfall is the only potential source of recharge and most of it is consumed by plants. Monthly recharge for 12 different land use types in the modeled area was calculated for 1949-1990 using a soil-moisture and pipe leak accounting algorithm developed by the USGS (Phillips et al., 1992). The simulations accounted for increasing urbanization of the Daly City area during the 1950s and 1960s by varying land use and associated recharge, and annual variations in rainfall throughout the simulation period.

Average annual recharge at the present level of development is approximately 5,630 acre-feet per year (af/yr) in the area covered by the groundwater model. One af equals 0.326 million gallons. In addition, approximately 440 af/yr of recharge occurs on hilly bedrock areas to the east and enters the basin as subsurface inflow. About 5 percent of the recharge occurring in the modeled area is from undeveloped lands, and 22 percent is from golf courses, parks, and cemeteries. Average annual evaporation from Lake Merced (approximately 27 inches) exceeds average annual rainfall (21 inches), resulting in an average annual net loss of about 190 af of groundwater.

6.2.4 Pumpage

Major pumping wells in the modeled area are shown in Figure 6-1. Total pumpage in the modeled area averages about 6,140 af/yr, about 70 percent of which is at municipal wells in Daly City. Historical pumpage estimates for municipal wells in the modeled area were available in 5-year increments (Applied Consultants and C/REM, 1991). These were disaggregated into annual pumpage estimates based on known dates of well drilling and general trends in historical urban development. Model calibration indicated that in some years the assumed distribution of pumpage among the municipal wells was incorrect, and a revised distribution was assumed that resulted in improved simulation of historical water levels. Irrigation pumpage at cemeteries and golf courses was estimated using the soil moisture accounting algorithm. At Olympic Golf Club (the only golf course for which metered pumpage data were available), estimated pumpage approximately equaled metered pumpage. Estimated municipal, irrigation, and total pumpage during 1949-1990 is shown in Figure 6-3.

6.2.5 Water Levels

Records of historical water levels in wells and Lake Merced are incomplete, especially for years prior to 1980. Well locations are shown in Figure 6-1. Figure 6-4 shows hydrographs of water levels during 1949-1990 in South Lake, Impound Lake, and six wells in the modeled area. These figures show overall declines in Lake Merced, San Francisco Golf Club wells, Daly City municipal wells and the cemetery wells. Stable to rising water levels are observed in the Stern Grove and Santiago wells.

Near the north end of the modeled area, groundwater in the shallow aquifer generally flows from east to west, which was the natural flow direction prior to groundwater development. In areas south of about the middle of South Lake, shallow groundwater flows southward toward areas of heavy pumping at golf courses, municipal wells, and cemeteries. Although the major pumping wells all draw from the deep aquifer system, the drawdown propagates upward through the clay confining layer and also affects water levels in the shallow aquifer. The difference in water levels between South Lake and Impound Lake provides visual evidence of the southward gradient. The two lakes are separated by a narrow permeable sand berm, and the water level in Impound Lake in 1990 was about 1.5 feet lower than in South Lake.

Maps of water levels in September, 1990 are shown in Figures 6-5 and 6-6 for the shallow aquifer and deep aquifer system, respectively. Water levels in the deep aquifer system near the southern end of Lake Merced (where shallow and deep water level data are both available) were 30 to 60 feet lower than in the shallow aquifer in 1990. Water levels were even deeper farther south, reaching lows of about -100 to -130 feet near Daly City municipal wells and the cemeteries. These data indicate that a downward gradient exists between the shallow and deep aquifer systems.

6.2.6 Model Calibration

The hydraulic conductivity, storage coefficient, vertical leakance, and ocean boundary conductance for each model layer were calibrated using a transient simulation with annual time steps for the 1949-1990 period and a transient simulation with semi-annual time steps for the 1982-1990 period. The first simulation was particularly useful in evaluating long-term storage processes in the groundwater basin and calibrating the vertical leakance across the clay confining layer. The second simulation allowed calibration of short-term storage responses and factors that affect seasonal water level fluctuations in the shallow and deep aquifer systems.

Hydrographs of simulated water levels in Lake Merced and at wells for which measured water levels are available are shown, along with the measured water level data in Figure 6-4. Simulated water level contours for September, 1990 are shown in Figures 6-5 and 6-6. In general, simulated water levels closely matched measured water levels in nearby wells.

6.3 GROUNDWATER BUDGETS

Groundwater budgets for the modeled area during three recent years with different climatic conditions are shown in Table 6-1. Water years 1983, 1985, and 1990 were selected to represent wet, normal, and dry conditions, respectively. Groundwater recharge, pumpage, and inflow from upgradient bedrock areas were calculated prior to the simulation using methods described earlier. Outflow to the ocean and storage changes are calculated by the model. These latter flows are affected by water levels. In essence, the model iteratively estimates the solution set of water levels for each model time step until mass balance is achieved in the overall water budget. The residual imbalance may be made as small as desired by specifying more precise closure criteria for the iterative calculations, but increased precision substantially increases the amount of computation time required for a simulation.

Groundwater recharge ranges from about 63 percent to 193 percent of normal, and pumpage ranges from about 86 percent to 104 percent of normal. The percentage variation in pumpage is smaller than the variation in recharge because indoor water use (which constitutes the majority of municipal use) and evaporative demand during summer are less variable than rainfall. Also, recharge from rainfall is negligible unless rainfall exceeds a threshold amount required to saturate surface soils in the root zone. Greater amounts of rainfall result in substantially larger amounts of recharge. Consequently, the temporal distribution of rainfall recharge is skewed, with large amounts occurring in a few years and little or none occurring in many years. Recharge from leaky pipes and irrigation return flow are not highly variable. In the Lake Merced area, these sources of recharge moderate the large fluctuations in rainfall recharge.

The groundwater budgets suggest that in all three years, groundwater outflow to the ocean occurs in some areas while seawater intrusion occurs in others. Flow across the ocean boundary did not reach a "steady state" during the simulation, even though pumping and recharge patterns were relatively stable during the last 20 years of the simulation. The effects of overdraft near Daly City and the cemeteries continued to spread northward and westward, gradually decreasing the amount of groundwater outflow and increasing the amount of intrusion. This trend is shown in Figure 6-7. In 1990, the year with the largest amount of seawater intrusion, intrusion was estimated at 1,213 af (395 mgal), or 18 percent as large as total pumpage during that year.

6.4 EFFECTS OF WELL PUMPING AND DROUGHT ON LAKE LEVELS

The groundwater model, with the input parameters described above, was used to simulate the effects of well pumping and drought on lake levels. This was done by "turning off" well pumpage rates that were input into the model as discharge parameters and observing the resultant "rise" in lake levels.

6.4.1 Historical Effects of Golf Course and Municipal Well Pumping

The effect on lake levels of pumping from wells at Harding Park, San Francisco Golf Club, Olympic Golf Club, and Lake Merced Country Club golf courses was estimated by simulating the 1949-1990 period without those wells. Irrigation water was assumed to be supplied from some other source. Consequently, groundwater recharge from irrigation return-flow at the golf courses was the same as in the calibration simulation. The amount of pumpage at the golf courses increased from 960 af in 1949 to an average of 1,050 af/yr during 1971-1990.

The resulting simulated water levels are shown in Figure 6-8 and are consistently approximately 4 to 5 feet higher than historic water levels. This difference was achieved within approximately 15 years and remained fairly constant thereafter. Annual water level fluctuations remained approximately the same as under historical conditions because all other model parameters related to recharge and other means of discharge were based on 1949 to 1990 data. Water level effects at seven additional locations are shown in Appendix K, Figure K-3.

The historical effect on lake levels of pumping from Daly City municipal wells was simulated by omitting all municipal pumpage during the entire 1949-1990 period. The results of the simulation are shown in Figure 6-8 and indicate that without Daly City municipal pumpage, lake levels would have been approximately 10 feet higher than historical lake levels. This difference developed gradually during the first 30 years of the simulation and remained fairly constant thereafter. Water level effects at seven additional locations are shown in Appendix K, Figure K-4.

To illustrate just the effect of pumping location, an additional simulation was done in which Daly City municipal pumpage was decreased by an amount equal to total golf course pumpage in each year during 1949-1990. The simulation is comparable to the one in which golf course pumpage was omitted, except that the pumpage decrease occurred farther from Lake Merced. The results are shown in Figure 6-8. The effect on lake levels was only half as large as the effect when golf course pumpage was omitted. This means that per unit of pumpage, pumping from wells close to the lake has a larger effect on lake levels than pumping from wells farther from the lake.

6.4.2 Effects of Drought

Land use patterns and Daly City municipal pumpage remained fairly constant during 1971-1990, and this was also a period during which average annual rainfall equalled the long-term average. Fluctuations in water levels during that time were largely the result of variations in pumpage and recharge associated with variations in climatic conditions.

Measured lake levels during 1971-1986 deviated by up to plus or minus approximately 3 feet from the average long-term trend (Figure 6-4). Between 1986 and 1990, annual rainfall averaged approximately 12.6 inches (61 percent of normal), and lake levels declined approximately 8 feet. The annual rate of decline was slightly greater than during the 1976-1977 drought, even though annual rainfall averaged only 9.6 inches during that two-year period. The disproportionately large rate of decline during the recent drought probably resulted in part from the longer duration of the drought. Because of storage effects in the groundwater basin, water levels respond gradually to changes in pumpage and recharge. During simulations of water resource alternatives, for example, water levels often continued to re-adjust for 15 or 20 years following a change in hydrologic regime.

6.5 EFFECT OF ADDING WATER TO MAINTAIN HIGH LAKE LEVELS

6.5.1 Short-Term Effects

Because Lake Merced is coupled to the surrounding shallow aquifer, water added to the lake immediately begins seeping out of the lake. This lowers the lake level and raises the adjacent water table, and the process continues until both reach the same elevation. In other words, the lake level cannot be raised for very long unless the adjacent water table is also raised. It also means that to raise lake levels for an extended period, more water must be added to the lake than the amount needed to raise the body of the lake itself.

Seepage processes are gradual, and the process of water level re-adjustment following a sudden addition of water to the lake will occur over a period of months. The rate of re-adjustment was investigated using the groundwater flow model by simulating the response following a sudden 4-foot increase in lake level. Results of the simulation are shown in Figure 6-9. About 360 mgal of water would be required to raise the lake level by this amount. Initial water levels for this, and all other future simulations described in this report, were the simulated water levels for 1990 of about 18.5 feet (10 feet MSL) obtained from the historic calibration simulation. However, the simulated 1990 water level in South Lake was almost 3 feet higher than the 1990 measured water level of 15.5 feet (7 feet MSL) because the model did not completely match the progressive water-level decline during 1985-1990. In the case of short-term effects of increasing lake levels, the initial lake level would probably be approximately 3 feet lower than what is shown in Figure 6-9. As a historical note, 400 mgal of City water was added to the lake in May, 1978.

The simulation assumed that other recharge and pumping stresses and initial water levels were the same as they were in 1990. The lake level rise was simulated as an instantaneous event by manually increasing the initial water level by 4 feet only in those model grid cells corresponding to the lake. The simulation was carried out for 42 time steps of 10 days each. For ease of interpretation, recharge and pumpage were held constant during the simulation. In reality, seasonal variations in pumpage and recharge during a 420-day period would create water level fluctuations that would be superimposed on the simulation results shown here. For comparison, a reference simulation was done without raising initial water levels in the lake.

As would be expected for a head-dependent equilibration process, the rate of decline from the initial lake level slowed with time. Relative to the reference simulation, the water level declined approximately 1.5 feet within the first 150 days and less than 1 foot during the next 270 days. At the end of the simulation, 14 months after the water was added to the lake, the lake level was still 2 feet higher than the reference simulation. These results indicate that slightly more than half of an artificial lake level increase would remain after one year. The effects on water levels in nearby wells are shown in Appendix K, Figure K-5.

6.5.2 Long-Term Effects

ADDING WATER FROM AN EXTERNAL SOURCE

To simulate the long-term effects of adding water to Lake Merced at a constant rate, a simulation was done of a future 42-year period in which 100 mgal of water was added to the lake at a constant rate every year. This is equivalent to a constant inflow of 190 gallons per minute (gpm). The water was assumed to be obtained from some external source, such as the Hetch Hetchy system, rather than from a local well. Initial water levels were assumed to equal simulated 1990 water levels. However, as above, the initial simulated reference point is actually 3 feet higher than the measured level. In terms of long-term effects, the result of starting the 1991-2032 simulations with water levels 3 feet too high is that slightly fewer years elapse before the groundwater system fully adjusts to the pumping and recharge regime assumed in each simulation. There is no effect on the long-term lake level ultimately reached during the simulation. Irrigated acreage, urban development, and municipal pumpage were set to conditions that existed in 1990. The sequence of annual rainfall was assumed to be the same as during 1949-1990. Thus, the simulation represents the period 1991-2032 under existing levels of urban and water supply development, assuming that climatic conditions during the next 42 years would be the same as during the last 42 years.

The simulation is a prospective investigation of what would happen during the next 42 years if one began adding water to the lake now, rather than what would have happened during the last 42 years if water had been added throughout that time. For comparison, a reference simulation was done of the future period in which no water was added to the lake. The reference simulation represents the "no action alternative" that results in a long-term lake level of approximately 21 feet (12 feet MSL).

In both simulations, irrigation water for HPMGC was assumed to be supplied from the municipal water system rather than from the lake or a local well, as is known to be the case as of approximately 1990.

The results of the simulations are shown in Figure 6-10. With the additional water, lake levels rose approximately 3 feet relative to the reference simulation during the first 20 years of the simulation and remained approximately that much higher for the remaining 22 years. The lake level stabilized at approximately 23.5 feet (15 feet MSL). Effects on water levels at other locations are shown in Appendix K, Figure K-6.

ADDING WATER FROM A LOCAL DEEP WELL

A second simulation was done in which 100 mgal of water was added each year from the deep well drilled in 1990 at the OWPCP site. As shown in Figure 6-10, the lake level did not increase as much as when the water was obtained from an external source because pumping at the new well increases the seepage rate out of the lake at the same time it is discharging water into the lake. Relative to the reference simulation, water levels rose about 1.5 feet during the first 20 years of the simulation and remained about that much higher. The lake level stabilized at about 22 feet (13.5 feet MSL). Effects on water levels at other locations are shown in Appendix K, Figure K-7.

6.6 AMOUNT OF EMERGENCY WATER AVAILABLE FROM LAKE MERCED

Because groundwater moves freely through the bed of Lake Merced, the lake functions like a large well penetrating the shallow aquifer. Thus, the amount of water that could be pumped from the lake during an emergency includes the amount of water in the lake plus the amount of groundwater that would flow into the lake when lake levels are drawn down by pumping. The magnitude of this inflow was estimated by simulating emergency pumping at a rate of 50 mgd for a period of 84 days. The initial lake level was set at the simulated lake level derived for September, 1990 of 18.5 feet (10 feet MSL), and ambient recharge and pumping rates were held constant throughout the simulation at the 1990 rates. As above, the reference simulation was approximately 3 feet higher than the measured water level.

Results of the simulation are shown in Figure 6-11. The water level declined about 7 feet over the 84-day period to an elevation of about 11.5 feet (3 feet MSL). Water levels were still declining at a rate of about 1.8 feet per month at the end of the simulation, and were about 2.5 feet higher than the minimum pumping level of 9 feet (0.5 feet MSL). If the initial water level had been set equal to the measured water level in September, 1990, the amount of water-level decline would have been about the same and the lake level would have reached the minimum pumping level at the end of the 84-day simulation period. Simulated effects on water levels in nearby wells are shown in Appendix K, Figure K-8.

Because lake levels were relatively low in 1990, this simulation provides a conservative estimate of the amount of emergency water available. The lake level approximately reached the minimum pumping level after 84 days of pumping at 50 mgd, which is about half the normal water use rate for the entire City of San Francisco. This period of time would probably be sufficient to repair any damage to the Hetch Hetchy water system that might suddenly result from an earthquake or other natural disaster.

Section 7

ALTERNATIVE WATER RESOURCE STRATEGIES

Several potential water resource strategies were evaluated using the groundwater flow model. Each strategy represents a single type of action and is implemented to the extent necessary to increase the future long-term average water level in Lake Merced 21 feet to 26 feet. As in Section 6, the reference simulation was approximately 3 feet higher than the measured level in 1990. However, there is no effect on lake long-term lake levels ultimately reached during the simulation.

Most of the individual strategies were able to achieve the target lake level. None of the strategies are mutually exclusive, so the target level could also be achieved by using a combination of strategies implemented to varying extents. A summary of effects of water resource alternatives on water levels in Lake Merced is provided in Table 7-1.

The effects of possible future increases in groundwater pumpage for municipal purposes by Daly City or the SFWD were also investigated to determine the extent to which they would lower lake levels.

7.1 ADD WATER DIRECTLY TO THE LAKE

7.1.1 Imported Water

The effect of adding 100 mgal of imported water to Lake Merced every year during 1991-2032 was described in Chapter 6. Simulated water levels were shown in Figure 6-10 and in Appendix K, Figure K-6. Briefly, water levels were raised by approximately 3 feet relative to the reference simulation. Subsequent simulations indicated that water would need to be added at a rate of about 170 mgal per year (0.5 mgal per day) to achieve an average lake level of 26 feet (17 feet MSL).

7.1.2 Local Well Water

The effect of adding 100 mgal of water to the lake every year from the deep well at the OWPCP was described in Chapter 6. Simulated water levels were shown in Figure 6-10 and Appendix K, Figure K-7. Briefly, water levels were raised by approximately 1.5 feet relative to the reference simulation. Subsequent simulations indicated that the well would have to discharge into the lake at a rate of about 250 mgal per year to achieve an average lake level of 26 feet (17 feet MSL). This is equivalent to a continuous pumping rate of 475 gpm.

7.1.3 Stormwater Runoff

Lake levels could be periodically raised by diverting flow in the Vista Grande stormwater conveyance canal into Impound Lake or South Lake. Daily flow in the canal was estimated using daily rainfall at San Francisco Airport and assuming the drainage area is 70 percent impervious. To avoid diverting relatively dirty "first-flush" runoff that occurs at the beginning of rainstorms, diversions were assumed to be accomplished using a weir that would bypass flows less than 24 cubic feet per second (cfs). This corresponds to a daily rainfall of 0.5 inch. Flows in excess of 24 cfs, up to a maximum diversion rate of 15 cfs, were assumed to be available for conveyance to South Lake by means of a culvert under John Muir Drive.

Daily diversion amounts were summed to obtain an annual amount of water diverted into the lake. This amount ranged from 47 to 655 af (15 to 213 mgal) and averaged 288 af (94 mgal). These amounts were added to the reference simulation for 1991-2032, which assumed the same annual sequence of rainfall as the 1949-1990 period. Annual diversion amounts during 1991-2032 and daily diversion amounts in selected years representing normal, wet, and dry conditions are shown in Figure 7-1.

Results of the simulation are shown in Figure 7-2. The water level increased to approximately 3.5 feet higher than the reference simulation within the first 20 years of the simulation and remained that much higher thereafter. The lake level stabilized at around 24 feet (15.5 MSL). Effects on water levels at other locations are shown in Appendix K, Figure K-9.

The influx of stormwater during rainy periods would cause a relatively rapid but small increase in the lake level. For example, the total amount of simulated stormwater diversions during a large 5-day storm in January 1983 was 112 af (36.4 mgal). Assuming the culvert between North and South Lakes was open, the lake level would rise 3.5 inches during the 5-day period.

The combination of bypass flow and maximum diversion rate selected for this simulation did not quite achieve the target lake level of 26 feet on a long-term basis. A higher lake level could be achieved using a larger culvert with a larger maximum diversion rate. For example, a maximum diversion rate of 30 cfs would add an average of 431 af per year (140 mgal per year) to the lake and result in an average lake level of 26.5 feet (18 feet MSL). A maximum diversion rate of about 27 cfs would add an average of about 410 af per year (133 mgal per year) to the lake and would probably be sufficient to achieve the target lake level.

7.2 SUBSTITUTE IMPORTED OR RECLAIMED WATER FOR LOCAL GROUNDWATER PUMPAGE

7.2.1 Golf Course Pumpage

An average of approximately 1,100 af per year of groundwater is used to irrigate Harding Park, San Francisco Golf Club, Olympic Golf Club, and Lake Merced Country Club golf courses. This corresponds to an average pumping rate of 0.99 mgd or 360 mgal per year. The effect of irrigating one or more of these golf courses with either imported or reclaimed water is shown in Figure 7-3. The hydrographs show the incremental effect of converting each additional golf course, beginning with Harding Park and continuing with San Francisco Golf Club, Olympic Golf Club, and Lake Merced Country Club. The reference simulation used throughout this chapter assumed that Harding Park would be irrigated with imported or reclaimed water; thus it corresponds to the second lowest curve on the graph. The source of irrigation water for HPMGC was switched from direct pumping out of Lake Merced to municipal water in 1990.

Converting Harding Park, San Francisco Golf Club, and Olympic Club golf courses to reclaimed or imported water raised the level of Lake Merced about 5 feet during the first 20 years of the simulation. Conversion of the Olympic Club had a slightly greater effect than conversion of the other two golf courses. The lake level stabilized at about 24 feet (15.5 feet MSL). Effects of water levels at other locations are shown in Appendix K, Figure K-10. Converting Lake Merced Country Club to reclaimed or imported water increased lake levels by only an additional 0.6 feet.

7.2.2 Municipal Pumpage

The effect on lake levels of decreasing Daly City municipal pumpage by 1.0 mgd (365 mgal per year) is shown in Figure 7-4. Pumpage at all municipal wells was decreased by 25 percent to achieve this reduction. Water levels in South Lake rose approximately 3.5 feet with respect to the reference simulation in the first 35 years of the simulation and remained that much higher thereafter. Lake levels stabilized at about 24 feet (15.5 MSL). Effects on water levels at other locations are shown in Appendix K, Figure K-11. However, decreases in Daly City municipal pumpage may not be economically feasible or realistic (Personal communication, Mr. Michael Abramson).

7.3 DECREASE OUTFLOW TO OCEAN WITH RECLAIMED WATER RECHARGE MOUND

The OWPCP is on the sand barrier between Lake Merced and the ocean. Reclaimed water from the plant could be used for artificial recharge of groundwater by means of a leach field along the sand barrier. This could elevate groundwater levels between South Lake and the ocean, thereby decreasing the rate of subsurface outflow along the western side of the lake. This possibility was incorporated into the groundwater model by including constant recharge at a rate of 1 ft/d along a linear leach field 100 feet wide and 4,000 feet long extending south from the wastewater treatment plant toward Fort Funston. The total application rate used was 0.4 mgd (146 mgal per year).

The effect of the artificial recharge on lake levels is shown in Figure 7-5. The lake level rose 7 feet with respect to the reference simulation in the first 15 years and remained that much higher thereafter. Lake levels stabilized at about 28 feet (19 feet MSL). Figure 7-6 shows contours of simulated water levels in the shallow aquifer. A contour interval of 1 foot is used to highlight the effect of the mound. Hydrographs showing the effects on water levels at other locations are shown in Appendix K, Figure K-12. The top of the mound is less than 2 feet higher than the level of South Lake, so there would be a small amount of reverse flow toward the lake. Reverse flow could be prevented by decreasing the artificial recharge rate or extending the leach field farther south to the vicinity of Fort Funston. Extending the leach field northward to include the OWPCP site might increase the risk of structural damage due to soil liquefaction during an earthquake. An additional study would be needed to evaluate this risk.

7.4 INCREASE MUNICIPAL PUMPAGE

Daly City and the SFWD are both considering increased groundwater pumpage from the Westside Groundwater Basin that includes Lake Merced. Increases in pumpage could result in further water level declines in Lake Merced. Simulations were done to illustrate the potential magnitude of the impact on lake levels.

7.4.1 Daly City

Daly City municipal pumpage for the 1991-2032 simulation was arbitrarily increased by 1.0 mgd (365 mgal per year), divided equally between two hypothetical new wells in the Westlake area. This area has been recommended for future groundwater development (Applied Consultants, 1991). One well was located near the intersection of John Daly Boulevard and Lake Merced Boulevard (Figure 4-1), and the other was located about 4,000 feet farther south. Effects of larger or smaller pumping rates would be different by an amount approximately proportional to the difference in the pumping rate.

The results of the simulation are shown in Figure 7-7. South Lake declined about 3.5 feet with respect to the reference simulation during the first 30 years of the simulation and may have continued to decline slightly thereafter. Because lake levels responded gradually, it is difficult to determine the equilibrium level of the lake. The trend appeared to be toward a level of about 17 feet (8.5 MSL). The effects on water levels at other locations are shown in Appendix K, Figure K-13.

7.4.2 San Francisco

A hypothetical municipal supply well for the SFWD was included in the 1991-2032 simulation. The well was located at 44th Avenue and Santiago Street and pumped from the deep aquifer system at an arbitrary rate of 1 mgd (365 mgal per year). Because the well was close to a no-flow boundary of the modeled area, simulated drawdown effects are exaggerated. The exaggeration approximately equals the effect of having a second well pumping at the same rate at a location near 44th Avenue and Moraga Street.

The results of the simulation are shown in Figure 7-7. South Lake remained at about the 1990 simulated level of 18.5 feet (10 feet MSL) rather than rising like the reference simulation to an equilibrium level of about 21 feet (12 feet MSL). Effects on water levels at other locations are shown in Appendix K, Figure K-14.

7.5 POTENTIAL WATER QUALITY IMPACTS OF WATER RESOURCE ALTERNATIVES

The water resource alternatives described above are characterized by widely varying water chemistries. Thus, variable water quality impacts to Lake Merced from the various proposed water sources are expected. Many water quality parameters, such as minerals, conductivity, and TDS, are defined as conservative parameters, meaning that the quality of the blended water (lake plus external source) is obtained by performing mass balance calculations. This simply means that the parameter concentration of the blend is equal to the parameter concentration of the lake times its volume, plus the parameter concentration of the external supply times its volume, all divided by the total resultant volume of the lake and the external source. For example, to analyze the impacts of conservative constituents contained within Vista Grande stormwater, a projection of water quality associated with the proposed volume additions can be made. The storage in Lake Merced is 1,210 mgal based on the long-term predicted level of 21 feet (12 feet MSL). If 133 mgal per year of Vista Grande stormwater is added to the lake, raising the lake level by 5 feet (See Table 7-1), then the lake volume will eventually be increased by 445 mgal (273 acres x 5 feet = 1,365 acre-feet, x 325,900 gallons per acre-foot). Based on available water quality data for the lake and stormwater (See Table 7-2), the lake conductivity of 641 micromohs becomes:

> 641 micromohs x 1,210 mgal + 56 micromohs (Vista Grande stormwater) x 445 mgal / (1,210 mgal + 445 mgal) = 483 micromohs expected from blending.

Other conservative parameters may be handled similarly. Key exceptions to the conservative mineral parameters are iron, manganese, and alkalinity.

Non-conservative water quality parameters are those that are subject to change after the initial blend due to chemical reactions and biological activity. The non-conservative parameters, including algae, dissolved oxygen, color, odor, coliform bacteria, temperature, turbidity, and iron and manganese, all may be impacted by the characteristics of the reservoir impoundment. For example, the occurrence of algae and algal blooms are enhanced by impounded water in part because of the quiescent conditions. Algae formation is further affected by the depth of water, light penetration, temperature, detention time, and attachment sites. Water temperature varies with depth, and may result in stratification, which can foster chemical changes (such as for iron and manganese). All these factors are in a dynamic state within a reservoir and vary with season, temperature, and depth. However, it may be possible to perform a simple modeling exercise to estimate resultant coliform bacteria using "background" bacteria concentrations measured in the lake, predicted bacteria concentrations in stormwater, and a range of possible "bacteria decay time." Bench tests could also be attempted, however they may not be accurate in replicating impound characteristics that effect the eventual resultant water chemistry.

Based on the discussions above, it is evident that some general statements may be made regarding blended water quality, but that for many constituents of concern, such as coliform bacteria or turbidity, resultant water chemistry is not easily quantified. General trends expected in lake water quality are itemized below:

7.5.1 Water Quality Impact of Adding Groundwater to Lake Merced

Lake Merced water chemistry is largely determined by the chemistry of inflowing groundwater. Thus, little change is expected in most of the parameters listed in Table 7-2. Due to increased lake volume, concentrations of parameters such as total coliform and total suspended solids may be reduced.

7.5.2 Water Quality Impact of Adding Hetch Hetchy Water to Lake Merced

Water quality impacts from adding Hetch Hetchy water to Lake Merced are expected to include a reduction in conductivity, alkalinity, chlorides, sodium. Because it is treated for total coliform prior to reaching San Francisco, the addition of treated Hetch Hetchy water is anticipated to reduce total coliform concentrations in the lake. Hetch Hetchy water would require de-chlorination before its discharge into Lake Merced.

7.5.3 Water Quality Impact of Adding Vista Grande Stormwater to Lake Merced

STORMWATER QUALITY

Potential water quality impacts of adding Vista Grande stormwater to Lake Merced can only be assessed using limited sampling data obtained by Kennedy/Jenks in 1984 and results from samples collected by DCDWWR in January and February, 1993. The Kennedy/Jenks sample results and the February, 1993 sample results were judged by Kennedy/Jenks and DCDWWR, respectively, to represent "first flush" conditions that would probably contain pollutants in greater concentrations than during average wet weather runoff conditions.

Comparison of measured stormwater quality with Lake Merced quality suggest that conservative parameters, including conductivity, hardness, and chlorides will be reduced. However, potential exists for increased total coliform, turbidity, and suspended solids (See Table 7-2). It should be noted that two parameters, total coliform and nitrogen, are not included in the DCDWWR sampling suite. Because bacteria concentrations and eutrophication are of concern in lake Merced, these parameters should be included in the stormwater sampling suite.

Based on Kennedy/Jenks and DCDWWR laboratory results, it appears that an increase in copper, lead, zinc, total coliform, turbidity, and suspended solids may be expected from adding Vista Grande stormwater to Lake Merced for the purpose of raising lake levels.

Results from two samples collected by DCDWWR indicate high suspended solids levels (2,900 mg/l and 600 mg/l in January and February, 1993, respectively) and 20 NTU and 6 NTU turbidity in January and February, 1993, respectively. These suspended solids levels are significantly higher than what was measured by Kennedy/Jenks in 1984 and need to be addressed in the design of the proposed conveyance canal. As discussed above, future concentrations of non-conservative parameters (coliform, turbidity and suspended solids) cannot be predicted within the scope of this report.

Prediction of conservative parameters (copper, lead, and zinc) can be made with the method used to calculate predicted conductivity above. Using this method, copper, lead, and zinc concentrations that could result from adding 5 feet of stormwater to the lake is predicted at 0.0068 mg/l, 0.015 mg/l, and 0.005 mg/l, respectively. These concentrations are below Drinking Water Standards of 1.3 mg/l, 0.05 mg/l, and 5 mg/l for copper, lead, and zinc, respectively (See Table 7-2).

In regard to suspended solids, turbidity and total coliform, it should be noted that if Daly City does construct a culvert to direct stormwater into Lake Merced, they also plan to include a settling system to reduce suspended sediment and turbidity concentrations, which could also reduce total coliform concentrations. A weir to skim off potential oil and grease constituents also may be constructed (Personal communication, Mr. Lee Yarborough). Additionally, compliance with Part II of the San Mateo Counties NPDES could indirectly result in lowering pollutant concentrations through compliance with BMPs.

POTENTIAL IMPACT OF WASTEWATER ON STORMWATER QUALITY

Within San Francisco, a sanitary sewer pipeline maintained by Daly City generally parallels Lake Merced between John Muir Drive and the Vista Grande culvert. The pipeline enters the Vista Grande culvert at the location where the culvert goes underground and discharges through an outlet tunnel (See Figure 7-2). Because both stormwater and wastewater flow out the Vista Grande culvert/tunnel by gravity, it is very unlikely that, during normal flow periods, wastewater could "back up" along the culvert and enter the conveyance canal proposed by Daly City to discharge excess stormwater into Lake Merced further upstream. When flow exceeds the capacity of the Vista Grande culvert, wastewater discharge is automatically diverted to a pipeline which is pumped out to the ocean (See Figure 7-2).

7.5.4 Water Quality Impact of Using Reclaimed Wastewater

IMPACT OF RECLAIMED WASTEWATER USED FOR IRRIGATION ON LAKE MERCED

Reclaimed wastewater for irrigation of the golf courses could be used to replace groundwater pumpage, thereby resulting in a lake level rise. Potential seepage of irrigation water into the groundwater flowing into the lake is most possible at the HPMGC, located directly upgradient of the lake.

The quality of the wastewater that could be used for irrigation is assumed to be similar to that which is currently produced at the Richmond-Sunset Wastewater Treatment Plant. Wastewater sampling results from this source is listed in Table 7-2. These data suggest that an increase in conductivity, chlorides, sodium, nitrogen, copper, and zinc could occur from irrigation with reclaimed wastewater. However, controlled irrigation practices could essentially eliminate the impact of irrigation seepage into the lake.

IMPACT OF RECLAIMED WASTEWATER MOUND ON LAKE MERCED

A mound of reclaimed wastewater created seaward of Lake Merced could reduce the rate of groundwater outflow into the ocean, thereby raising lake levels. If engineered correctly, this reclaimed wastewater mound would not be expected to impact the lake directly, thus impacts to lake quality would not be expected. However, during times of emergency pumping, lake levels would decline which could result in inflow from the wastewater mound. As above, wastewater sampling data from the Richmond-Sunset plant suggest that an increase in conductivity, chlorides, sodium, nitrogen, copper, and zinc could occur from inflowing wastewater. It is possible that this could be avoided by limiting the pumping so that inflow does not occur.

Section 8

LAKE MERCED WATER MANAGEMENT STRATEGY

The work performed in the current study represents only a portion of the work required to ultimately develop a Lake Merced Water Management Plan. This Section discusses the specific tasks required to complete the water management aspects and the integration with other relevant work, including the Lake Merced Recreation and Open Space Master Plan and the San Francisco Groundwater Master Plan (GWMP). The remaining work is summarized in Figure 8-1 and discussed as follows:

- Form a Lake Management Committee;
- Resolve Remaining Beneficial User Conflicts and Finalize Lake Level and Lake Quality Criteria;
- Implement Monitoring Program;
- Develop and Evaluate Water Resource Alternatives;
- Obtain Input to Alternatives Development;
- Recommend a Preferred Lake Merced Water Management Plan;
- Conduct Environmental Review;
- Adopt Plan and Implement;

8.1 FORM LAKE MANAGEMENT COMMITTEE

The multiple beneficial uses that Lake Merced offers requires that a permanent multi-department group be set in place to facilitate future decision making. Such a group should be focused on those departments that will have a long-term interest in the operation and maintenance of the lake to satisfy the established beneficial user requirements. It is suggested that as a minimum, the following governmental agencies provide a member for the Lake Management Committee (LMC):

- San Francisco Recreation and Park Department
- San Francisco Water Department (Engineering, Water Quality, and Operations)
- San Francisco Department of Public Works
- San Francisco Department of Public Environmental Health
- Daly City Department of Water and Wastewater Resources
- Regional Water Quality Control Board
- San Francisco Office of Environmental Review
- San Francisco Office of the City Attorney, Water Section

The LMC's key work will be to provide guidance for the development and evaluation of water management alternatives and the integration of the preferred Lake Merced Water Management Plan into a more comprehensive Lake Merced Management Plan which covers topics unrelated to lake management.

8.2 RESOLUTION OF REMAINING BENEFICIAL USER CONFLICTS

Based on discussions presented in Section 5, it appears that primary conflicts exist between beneficial uses and related water quality criteria, rather than between beneficial uses themselves. However, some additional conflicts between "low water" and "high water" beneficial uses and the rate at which to raise lake levels were identified at the April 26 public meeting. Resolution of conflicts with existing water quality criteria may be met if mitigations presented in Section 4 are implemented. Conflicts identified at the public meeting should be addressed by the future LMC using the guidelines recommended in Section 5.4. Afterward, the preliminary water level and water quality objectives presented in this study may need to be refined.

8.3 IMPLEMENT MONITORING PROGRAM

Once the specific lake level and water quality objectives are refined, the monitoring program recommended in Section 4 can be finalized. Such a program could require a more intensive short-term monitoring phase that would fill in gaps in the existing program in order to facilitate alternatives development and evaluation. The long-term program could incorporate those monitoring activities that would help in lake operation and in maintaining the desired water quality.

8.4 DEVELOP AND EVALUATE ALTERNATIVES

The key to satisfying the lake level and quality objectives is to enhance the existing Lake Merced capabilities with a plan of management activities and construction of physical facilities. As part of the current study, the impacts of certain "projects," such as adding Hetch Hetchy water or nearby groundwater, have been assessed in a preliminary manner in order to determine the quantity of water required to meet the stated water level objective of 26 feet. These "projects" should be formulated as alternatives and compared on some objective basis in order to establish their comparative merit. The development and evaluation of alternatives is not only required from an engineering standpoint, but is a key requirement of the California environmental compliance process, as discussed later. A reasonable range of alternatives should be formulated, including a no-action alternative. See Figure 8-2 for an overview of the alternatives development and evaluation procedure.

8.4.1 Water Management Elements

Lake management alternatives can be considered as composed of a set of non-structural and structural elements, which alone, or when combined, should satisfy the lake management objectives described in Section 5. Non-structural measures involve no facilities, but, are focused on the development and implementation of cooperative arrangements with other agencies that can impact lake level or lake water quality, as well as specific policies, programs, and ordinances which can preserve and enhance water quality. Structural elements, on the other hand, involve the construction of facilities that specifically address the lake level and water quality objectives. The available elements include the following:

- Non-Structural Management Elements
  - Inter-agency agreements;
  - City ordinances;
- Structural Management Elements
  - Add water directly to the lake using imported water (conceivably from the Hetch Hetchy system or from groundwater outside the lake capture zone);

- Add water from a deep well water from inside the lake capture zone;
- Increase stormwater runoff;
- Substitute reclaimed water for local groundwater used for irrigation;
- Decrease groundwater outflow to ocean by recharging coastal groundwater with reclaimed water.

The non-structural approach to management of Lake Merced would focus on maintaining the lake level and quality objectives through inter-agency agreements for the reduction and redistribution of groundwater extraction in the vicinity of the lake and controlling the impacts of other groundwater users that affect lake quality. City ordinances could then be developed to enhance lake water quality.

Preliminary assessments of water requirements of each structural element was provided for the years 1991 to 2032 using the groundwater model developed for this study. The results of the model simulation and the assumptions are discussed in Section 7.

8.4.2 Development of Water Resource Alternatives

Alternative courses of action are available to maintain Lake Merced at the desired level and water quality required by its defined beneficial uses. The alternatives must be formulated by combining non-structural and structural lake management elements in such a manner as to satisfy the established management objectives defined in Section 5.

In order to maintain the desired lake level at 26 feet, structural alternatives must include the introduction of supplemental water into the lake derived from one of the sources described above. To evaluate implementability and associated costs, the specific components (wells, pumps, pipelines, etc.) of the alternatives must still be developed.

In addition to these structural elements, the alternatives will incorporate certain management (non-structural) elements, many of which may be common to all the alternatives. For example, the mitigations presented in Section 4 of this report set forth recommended policies and actions which should help to meet the desired lake water quality objectives. Further, the extent of required structural measures can be minimized if memoranda of understanding or agreements could be developed to limit additional groundwater pumping in the capture zone of Lake Merced by the City of Daly City, the City of San Francisco (including Harding Park and the Zoo), San Francisco Golf Club, and Olympic Country Club.

Outstanding issues in relation to the introduction of supplemental water into the lake include the rate at which water should be introduced and the institution of a spillway structure in the event that future wet years results in excessively high lake levels. The rate at which water should be introduced into the lake should be slow enough that recreational and fish and wildlife habitat beneficial use requirements are satisfied. A satisfactory rate still needs to be determined prior to design of a system to introduce supplemental water to the lake.

According to various communications, a spillway may exist along the west side of Lake Merced, although its location is unclear. A spillway has been reported to exist along Impound Lake, which was designed to discharge into the Vista Grande culvert (Personal communication, Mr. Tom Dickerman). Historic records also refer to an outlet, consisting of 1,100 feet of iron pipe, at North Lake (Written communication, S.P. Eastman). In any event, the re-activation of a spillway should be considered if supplemental water is to added to the lake on a regular basis.

8.4.3 Evaluation of Water Resource Alternatives

The prioritizing of alternatives that strive to achieve the desired Lake Merced level and water quality should be objective, comprehensive, and well documented in order to survive legal challenges. An evaluation technique most commonly used is the development of a set of evaluation criteria to rate and compare each alternative to each other. The systematic evaluation and prioritizing (rating) of the alternatives can most conveniently be done in a matrix-type tabulation which shows the evaluation criteria arrayed against the alternatives and a descriptive or numerical rating of each alternative for each criteria. This technique was developed after enactment of the National Environmental Policy Act (NEPA) of 1969 and subsequent litigation for preparation of environmental impact reports. The technique has been expanded to not only include impacts to the environment, but also to incorporate economic and implementability aspects.

The key to the evaluation procedure is establishing evaluation criteria which should be responsive to project objectives and allow differentiation among the alternatives. For each of the evaluation criteria, a scale must be established which will allow differentiation among the alternatives. Scales may begin descriptively, but should then be converted to numbers, in order to permit summing the scores for each criteria item into a total alternative score. If alternatives are compared for costs, an easy numerical scale can be established which rates the alternatives between the lowest and highest cost and converts them to a scale. The highest cost could be "1", and the lowest cost alternative could be "3" (or "5", or "10"). Intermediate costs would be assigned a number that reflects the position between the lowest and highest cost.

For non-economic evaluation criteria, such as, for example, source reliability, a descriptive scale must be developed, which may be related to hydrologic variation and potential for interruption of delivery system, defining a range from poor to high reliability, where "poor" is equivalent to "1", and "high" is equivalent to "3" (or "5", or "10"). It is very important that the descriptors be as detailed as possible to allow differentiation among alternatives. For instance, "poor" source reliability could be assigned to a source that is subject to extreme hydrologic variation; where data is insufficient for long-term yield estimates; and which is subject to contract cutbacks from competing water users. Further, source reliability can be related to the potential for service interruption because it requires extensive, complicated treatment (power-dependent processes), or may be subject to seismic damage. Other criteria that could pertain to Lake Merced include flexibility, reliability, ease of staging, and implementability, as may be determined by public acceptance, potential legal issues to be resolved, and the number of permits required.

The final part of the evaluation procedure is to prioritize the alternatives according to their total scores. The initial assumption should generally be that all criteria are of equal weight. Weighting, if used, must be on a logical, sound basis that may be subject to environmental or legal challenge.

The preliminary matrix suggested for the Lake Merced Water Management alternative evaluation is presented in Figure 8-3. It should be noted that all "projects" may not individually restore the lake to the desired elevation, nor are they equally effective in obtaining the target water quality required for the defined beneficial uses. Therefore, the matrix incorporates the evaluation criteria "Meeting Lake Management Objectives" which allows rating the alternative projects based on the extent to which they meet the target lake quality and level.

For development of the Lake Merced Management Plan, it is suggested that the following preliminary evaluation criteria be considered:

- Meeting Lake Management Objectives
    - Water Quality
    - Water Level
- Economic Criteria
    - Equivalent Annual Cost (includes Capital and O&M)
- Non-Economic Criteria
    - Environmental Impact
        - Short-term
        - Long-term
    - Source Reliability
    - Flexibility
    - Implementability
    - Regulatory Requirements (permits)
    - Water Rights Issues

Examples of concerns to be addressed under Environmental Impacts would include the impact of water chemistry of the four alternate supplemental water sources and overall effects to the aquifer system from adding groundwater to the lake. Water from Hetch Hetchy, new wells, stormwater, and reclaimed wastewater have different water qualities which will impact lake quality to some degree. The resulting blended water quality cannot always be determined by a simple mathematical calculation since some quality characteristics (parameters) are non-conservative, such as pH, turbidity and total coliform, signifying that their concentration may change after initial blending due to chemical reactions and biological activity. Other parameters, such as algae, dissolved oxygen, odors, and temperature are also non-conservative and to a large extent determined by lake configuration and subject to seasonal and longer-term variations. Conservative parameters are those, such as the mineral parameters (TDS, chlorides, etc.), that are stable in water and, when sources are blended, result in a mix concentration that is proportional to the relative source concentrations and quantities of water.

Another environmental impact to consider is the benefit of indirectly recharging groundwater and nearby wells by adding water to Lake Merced. As the groundwater table rises, so will water levels in nearby wells. Recharging the groundwater system brings up the issue of water rights, which is briefly discussed below.

8.4.4 Water Rights Issues

As lake levels are restored, the encompassing aquifer system is replenished and a portion of the added water will eventually seep through the underlying clay layer and flow towards pumping wells. In the case of Daly City municipal wells, an issue may be raised by the City of San Francisco that water owned by the City is being provided, free of charge, to Daly City wells. To resolve such issues, it is possible that an agreement may be worked out between the two cities that best utilizes Hetch Hetchy water and groundwater. For instance, Daly City could reduce groundwater pumping in wet years in order to reduce inflow from Lake Merced.

Currently, the Westside Groundwater Basin is unadjudicated, making it very difficult for the City to proceed in regional groundwater planning. The City has previously requested information on the complexity and cost of groundwater adjudication in a letter from Mr. Art Jensen of the PUC to Mr. George Krueger of the City Attorney's Office (January 18, 1990). However, according to Mr. Josh Milstein, the process is very time-consuming and the cities involved may find solutions to regional groundwater problems easier to solve through inter-agency agreements (Personal communication, Mr. Josh Milstein).

8.5 OBTAIN INPUT TO ALTERNATIVES DEVELOPMENT

Input is required during the formulation of alternatives in order to make them responsive to the needs of the beneficial users and to assure that the preferred alternative is acceptable on environmental grounds, and can be implemented. Input would be obtained from the following:

- Lake Merced interest groups and general public;
- Governmental agencies not currently included in the LMC;
- San Francisco GWMP Steering Committee.

8.5.1 Lake Merced Interest Groups and General Public

Interest groups, as well as the general public in the vicinity of Lake Merced were identified through the SFRPD and informed of the public meeting held on April 26, 1993. This same group should be contacted periodically for public meetings to be held at critical decision points.

8.5.2 Governmental Agencies

Governmental agencies that are not currently included in the Lake Merced Steering Committee or have not participated in recent Task Force meetings, could require future contact, particularly if land modifications related to facility construction takes place. The California Coastal Commission retains coastal permit review jurisdiction over all the water area, historical tidelands, and historic wetlands, including historic channels, at Lake Merced. The Coastal Commission also maintains an appeal jurisdiction for projects within 100 feet of the water's edge at Lake Merced.

Proposed projects outside the water area, historic wetlands, and tidelands are reviewed by the Planning Department of the City and County of San Francisco. Such review is done within the context of the Local Coastal Program which is incorporated in the Western Shoreline Plan of the City's Master Plan. Any project which is approved through City Planning but lies within 100 feet of the water's edge of Lake Merced, may, however, be appealed to the State Coastal Commission.

Lake Merced is classified as a navigable waterway. Therefore, any proposed alteration of the lake itself must receive approval from the Army Corps of Engineers.

The California State Lands Commission has claimed title to the western portion of the Lake bed. This area was not included in the original Mexican land grant for the Rancho Laguna de la Merced and its ownership by the Spring Valley Water District has not been verified. Any alteration of the Lake bed or proposed development which would project above the Lake bed should receive approval from the Lands Commission.

The SFFD should be made aware of any future Operations Plans that the SFWD develops related to the treatment and distribution of Lake Merced water for emergency water use.

The DFG retains jurisdiction over fishing at Lake Merced. Caltrans has jurisdiction over the highway on the west side of Lake Merced.

8.5.3 San Francisco Groundwater Management Plan Steering Committee

Because Lake Merced is an integral part of a much larger groundwater system, alternatives to restore lake levels to satisfy beneficial user needs must necessarily consider the impact of other existing and potential groundwater users within the system. Alternative configurations must be coordinated under broader planning, such as that involved in the San Francisco GWMP, which has recently been initiated by the SFWD. Issues related to development and evaluation of water management alternatives would include:

- Water rights;
- Cost sharing;
- Additional studies related to potential water resource alternatives and modelling of impacts to the aquifer;
- Integration and use of Lake Merced water quality monitoring results by the GWMP team.

The goal of the GWMP is to establish a management strategy for each of San Francisco's seven groundwater basins (Westside, Lobos, Marina, Downtown, Valley, South, and Visitation Valley), that maximizes the use of these local water sources through integrated operation with other existing or potential water sources, including Hetch Hetchy and reclaimed water, putting the respective supplies to best beneficial use. The GWMP is intended to be a guidance document for the City, suitable to serve as the basis of design of required infrastructure. Since Lake Merced is primarily a surface feature of a portion of the Westside Basin, one of the basins to be studied in the GWMP, any lake management solutions must be integrated with that more comprehensive regional planning effort.

8.6 THE RECOMMENDED LAKE WATER MANAGEMENT PLAN

The water resource alternative with the highest rating and least environmental impacts should be developed into a Lake Water Management Plan (LWMP). Care must be taken in the final recommendation so that it agrees with the environmental review discussed below. The comparative merits of each of the water resource alternatives should be evident and clearly documented. The selected alternative should be capable of either eliminating any significant adverse environmental effects or reducing them to a level of insignificance.

LWMP elements could be integrated into an overall Lake Merced Management Plan which would address other park issues unrelated to water resource issues.

8.7 ENVIRONMENTAL REVIEW

According to CEQA, any activities directly undertaken by government, activities financed by government, or activities requiring a permit or other approval from government must be analyzed by the lead agency to determine the potential environmental effects. Management plans are included in the environmental review requirement because such plans control activities may involve construction of facilities, all of which may result in a physical change to the environment, directly or ultimately. The procedure to be followed in performing the environmental analysis under CEQA is detailed in the statute and in the CEQA Guidelines issued by the California Resources Agency.

The CEQA procedure involves a number of steps in producing an environmental document, which then becomes part of the record to support permit decisions. After the determination by the lead agency that the plan or project may have a significant effect on the environment, a Notice of Preparation (NOP) must be submitted to the State Clearinghouse, Office of Planning and Research. for circulation to responsible agencies. These agencies respond with their concerns as to the content of the environmental analysis within 30 days. During this time, a scoping meeting may be held by the lead agency to solicit additional input as to the EIR contents. A Draft EIR is prepared and circulated within a minimum review period of 30 days. A Final EIR is then prepared and certified that it is complete and has been considered by the decision makers of the lead agency. Mitigation issues are addressed, and a Notice of Determination filed with the County Clerk and the State Office of Planning and Research.

The environmental review process should focus on the development and evaluation of alternatives as noted in "Guidelines for Implementation of the California Environmental Quality Act," Section 15126: "...The key issue is whether the selection and discussion of alternatives fosters informed decision-making and informed public participation...." That is, the alternatives should not be developed in isolation from the users and the public, and then presented as a preferred alternative. Further, the alternatives and the evaluation procedure should be well defined and simplified. The EIR must produce information sufficient to permit a reasonable choice of alternatives so far as environmental aspects are concerned.

8.8 PLAN ADOPTION AND IMPLEMENTATION

The adoption and implementation of the LWMP will require certain actions by the lead agency as constrained by environmental, institutional, and legal requirements. The EIR Notice of Determination, as discussed above, is the final action that leads to plan or project adoption. The implementation of the LWMP will be guided by the engineering aspects of the non-structural and structural measures to be developed; by the standardized procedural requirements of the City departments involved; by the permitting requirements of the affected regulatory and permitting agencies; and by the general legal requirements for potential agreements. A chronological listing of detailed actions should be prepared that will begin with adoption of the recommended management plan, and cover coordination with other agencies, engineering, financing, permitting, and a lake level and water quality monitoring program that will form the basis for making operations decisions.

Section 9

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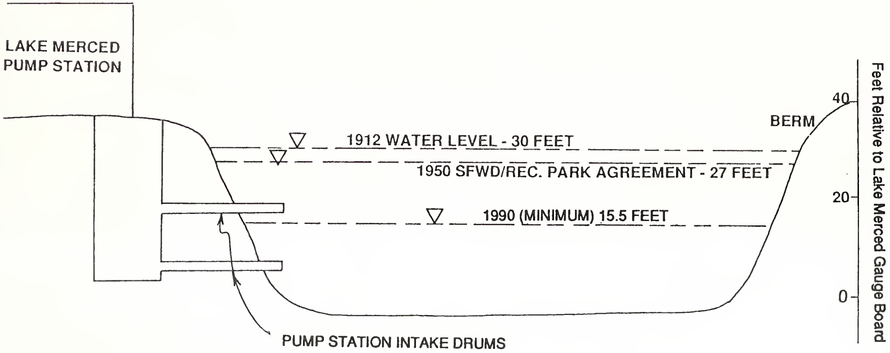
FIGURES


LAKE MERCED
PUMP STATION
1912 WATER LEVEL - 30 FEET
1950 SFWD/REC. PARK AGREEMENT - 27 FEET
1990 (MINIMUM) 15.5 FEET
BERM
PUMP STATION INTAKE DRUMS
Feet Relative to Lake Merced Gauge Board
40
20
0

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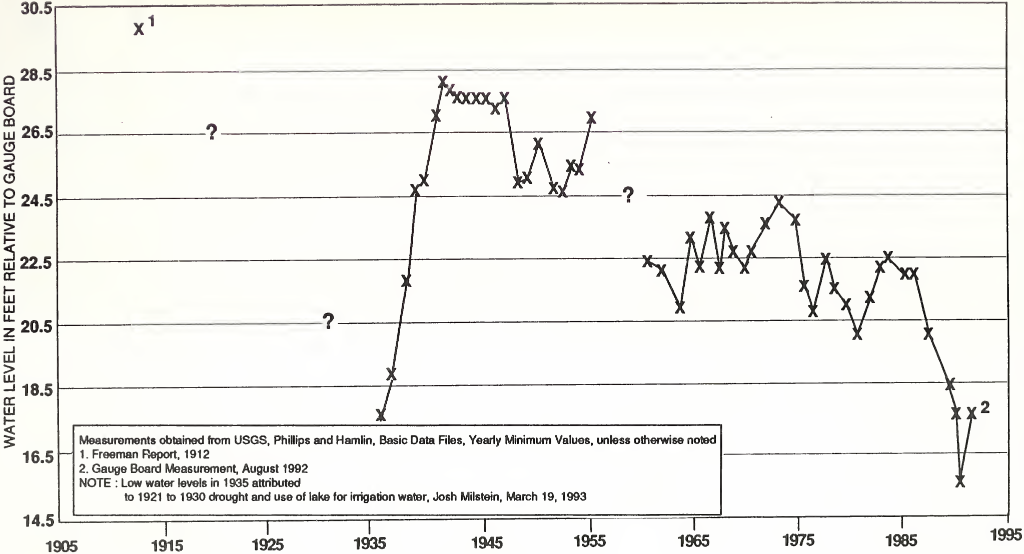
Job No. 1756-001 Appr Date 2/23/93

WATER LEVEL DECLINE IN LAKE MERCED
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
1-1



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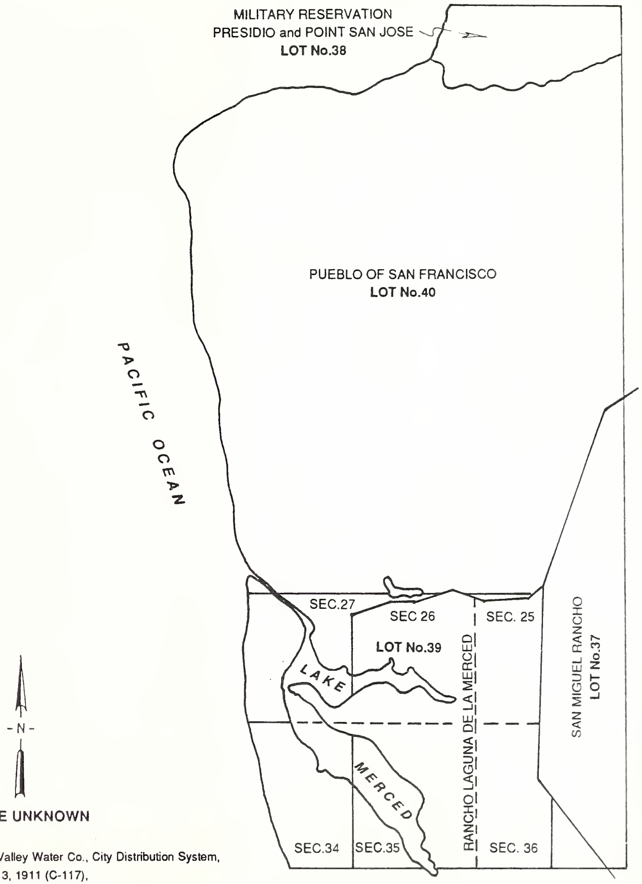
LAKE MERCED HISTORIC WATER LEVELS
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
1-2



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March 13, 1911 (C-117),
Compiled from Surveyor's General OFfice,
San Francisco, San Francisco, CA, November 18, 1972.

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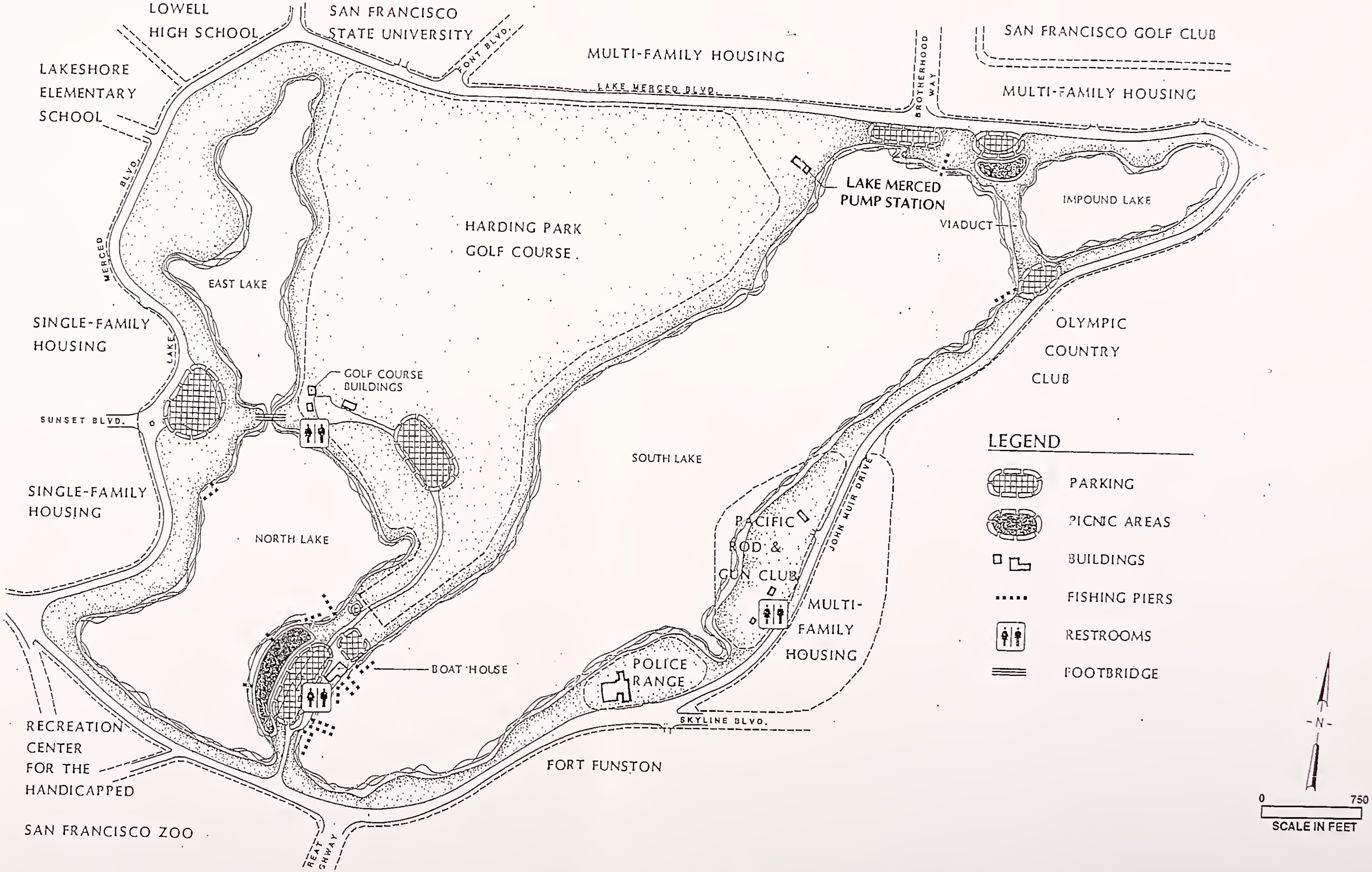
HISTORIC LAKE MERCED
LAKE MERCED WATER RESOURCE
PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
2-1



REFERENCE : Lake Merced Recreation and
Open Space Master Plan, Draft, June 1990
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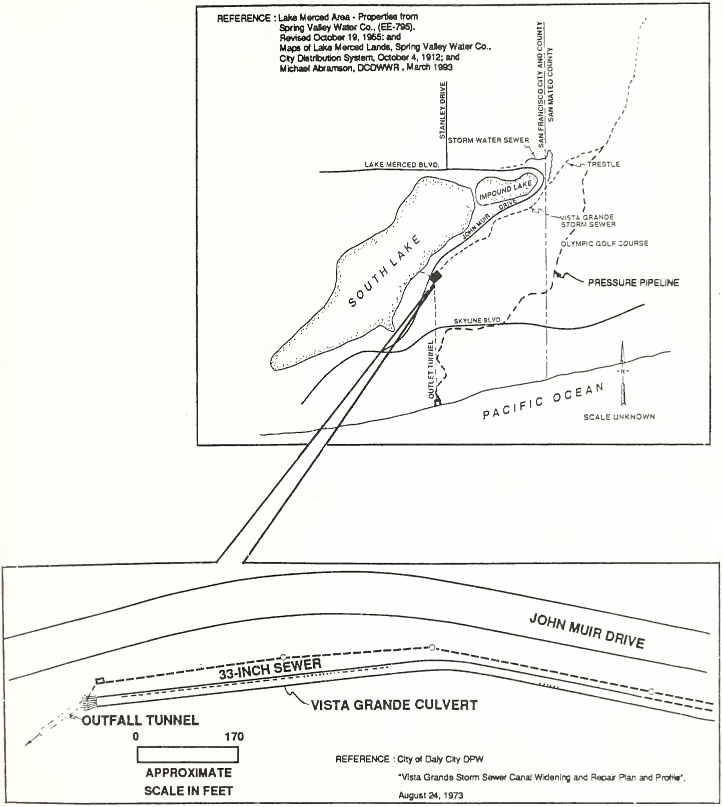
LAKE MERCED EXISTING LAND USES
LAKE MERCED WATER RESOURCE
PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
2-2



REFERENCE : Lake Merced Area - Properties from Spring Valley Water Co., (EE-795). Revised October 19, 1955: and Maps of Lake Merced Lands, Spring Valley Water Co., City Distribution System, October 4, 1912; and Michael Abramson, DCDWWR, March 1993

REFERENCE : City of Daly City DPW "Vista Grande Storm Sewer Canal Widening and Repair Plan and Profile", August 24, 1973

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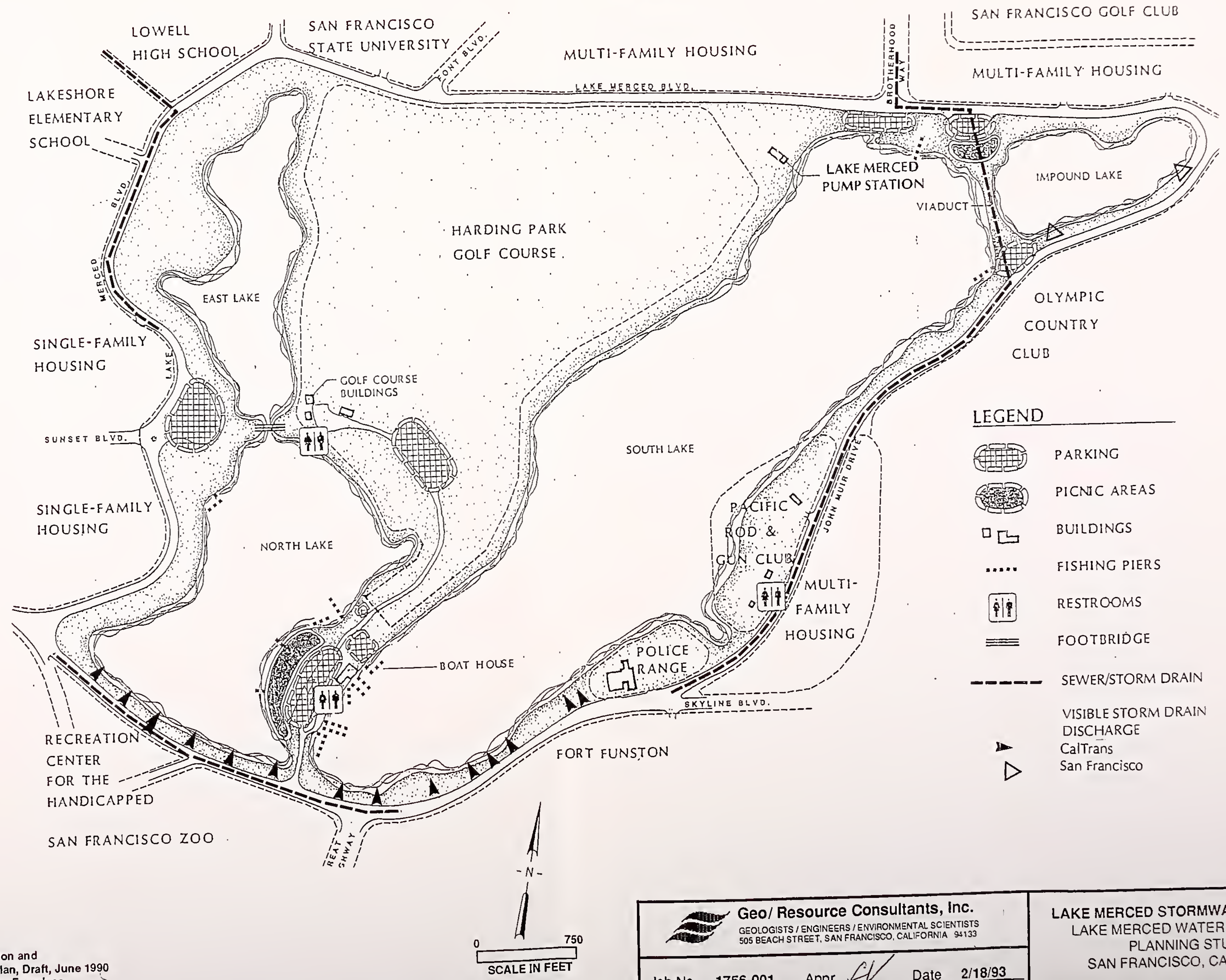
VISTA GRANDE CULVERT AND THE DALY CITY SANITARY SEWER OUTFALL
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
2-3



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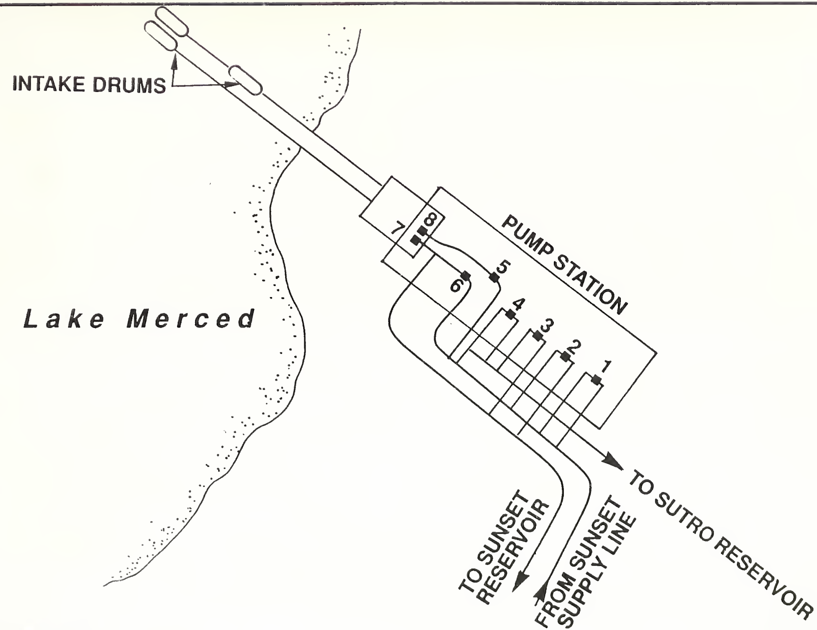
LAKE MERCED STORMWATER INFLOWS
LAKE MERCED WATER RESOURCE
PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
2-4

REFERENCE : Lake Merced Recreation and
Open Space Master Plan, Draft, June 1990
City and County of San Francisco



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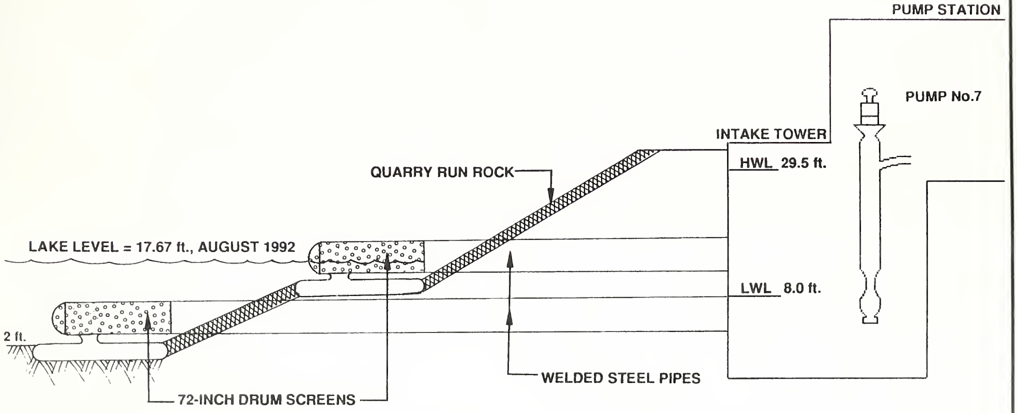
LAKE MERCED PUMP STATION
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
3-1



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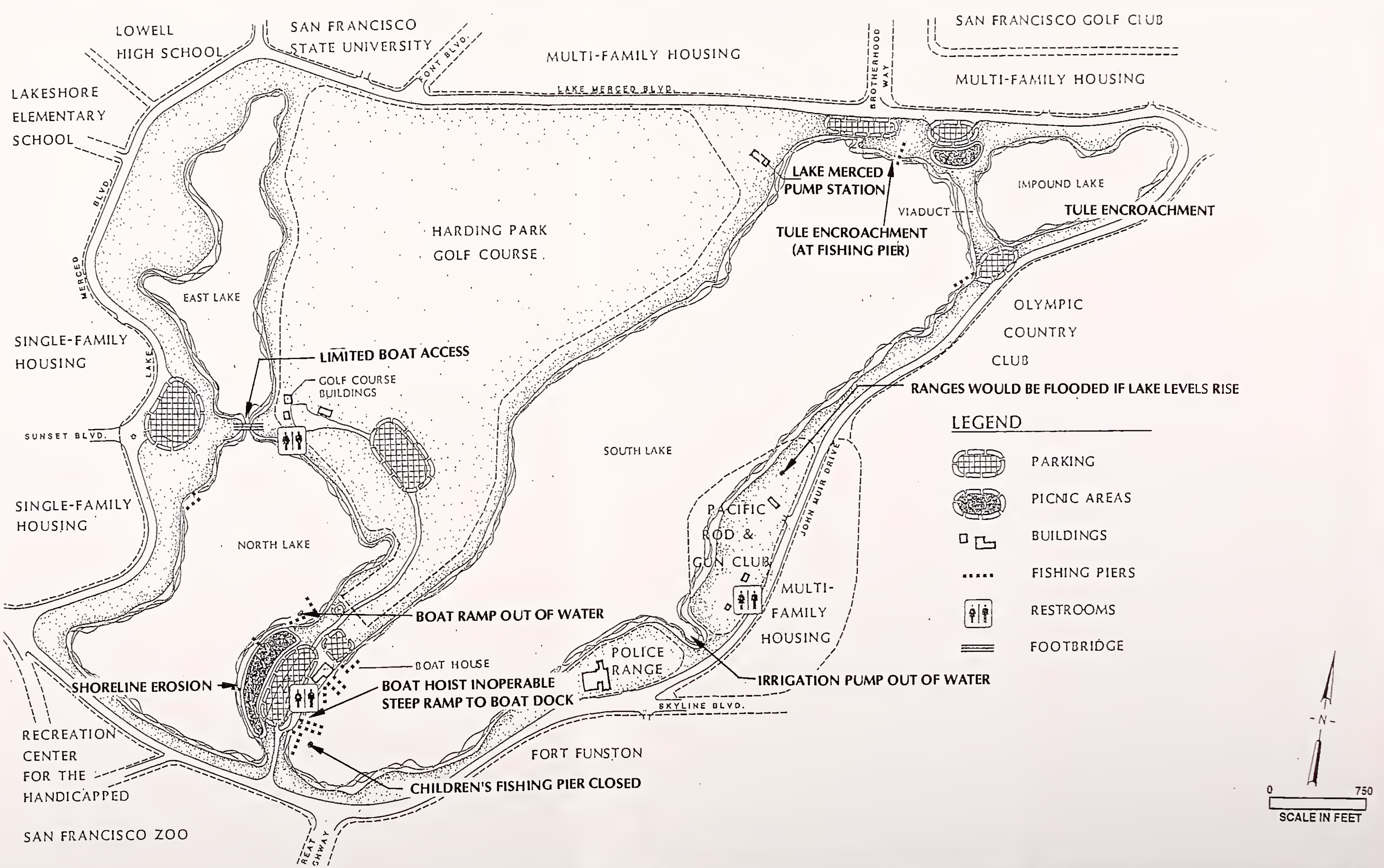
LAKE MERCED PUMP STATION INTAKE DRUMS
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE 3-2



REFERENCE : Lake Merced Recreation and
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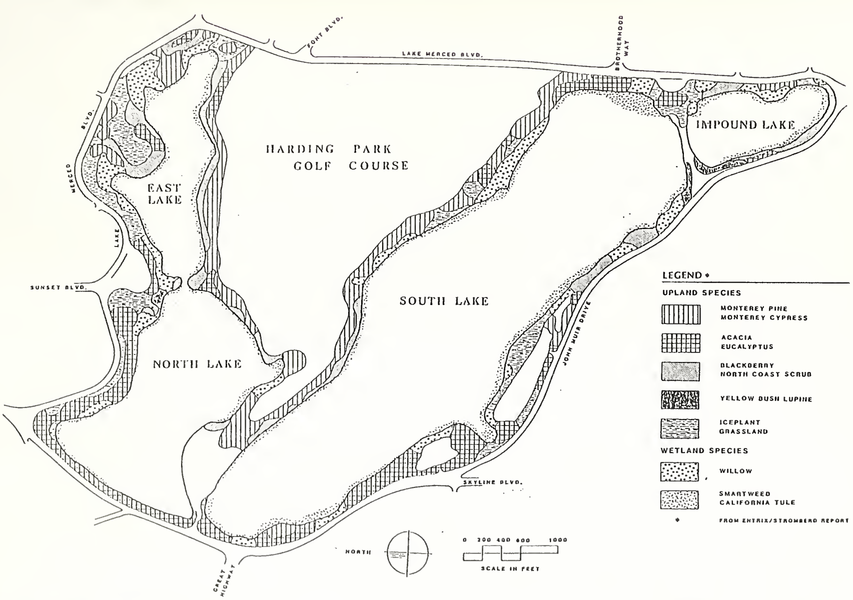
LOCATION OF EXISTING DAMAGE AND LAKE LEVEL IMPACTS TO RECREATIONAL FACILITIES AT LAKE MERCED
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
3-3



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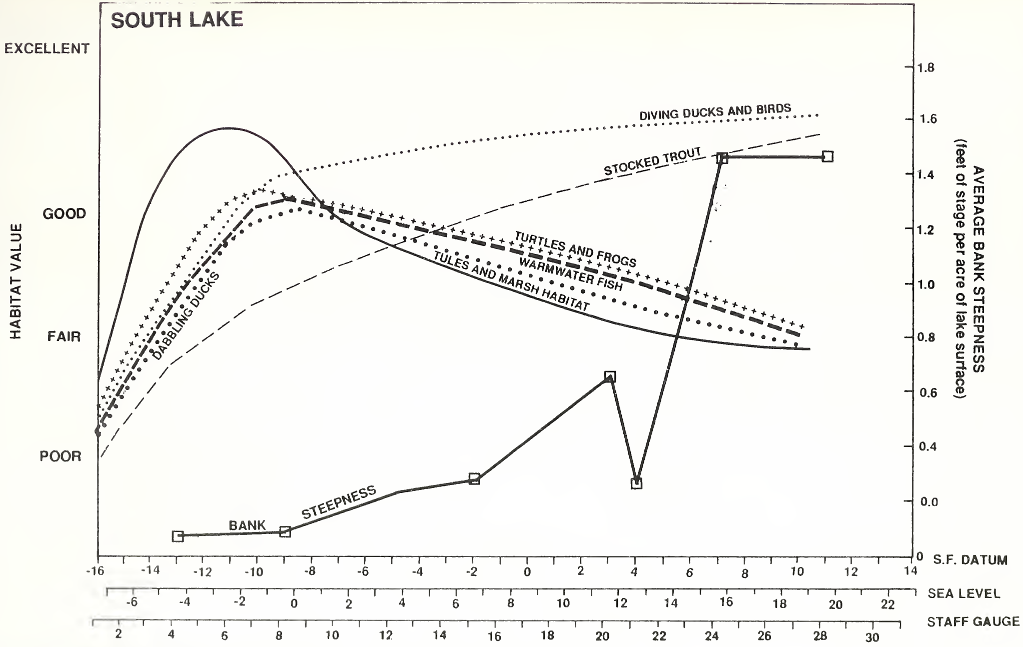
LAKE MERCED VEGETATION MAP
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
3-4



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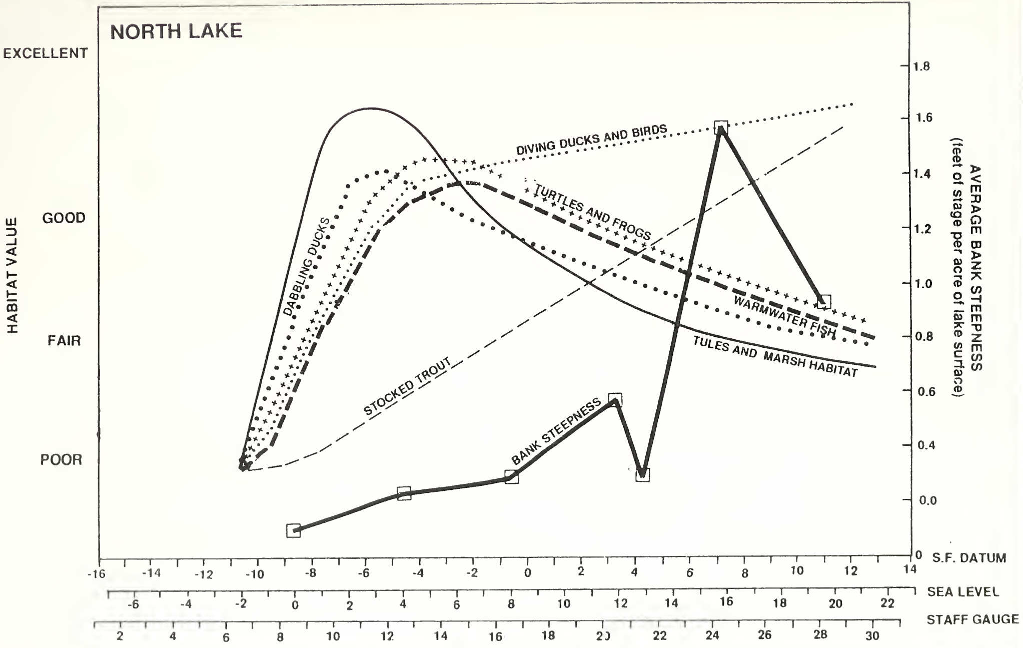
RELATION OF HABITAT VALUE AND BANK STEEPNESS TO WATER LEVEL IN SOUTH LAKE
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
3-5



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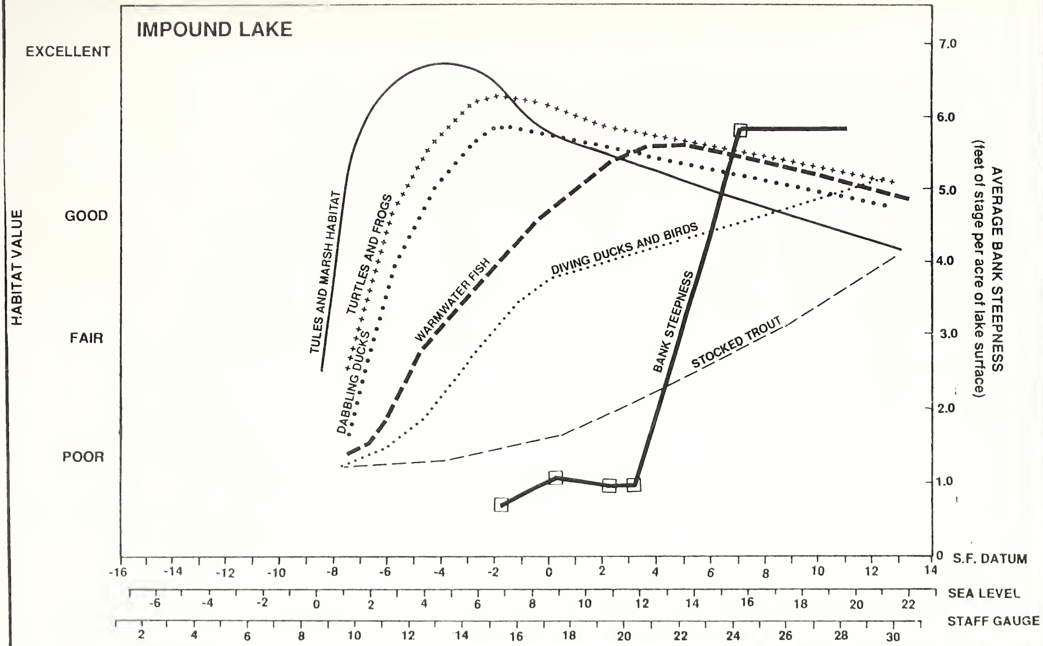
RELATION OF HABITAT VALUE AND BANK STEEPNESS TO WATER LEVEL IN NORTH LAKE
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
3-6



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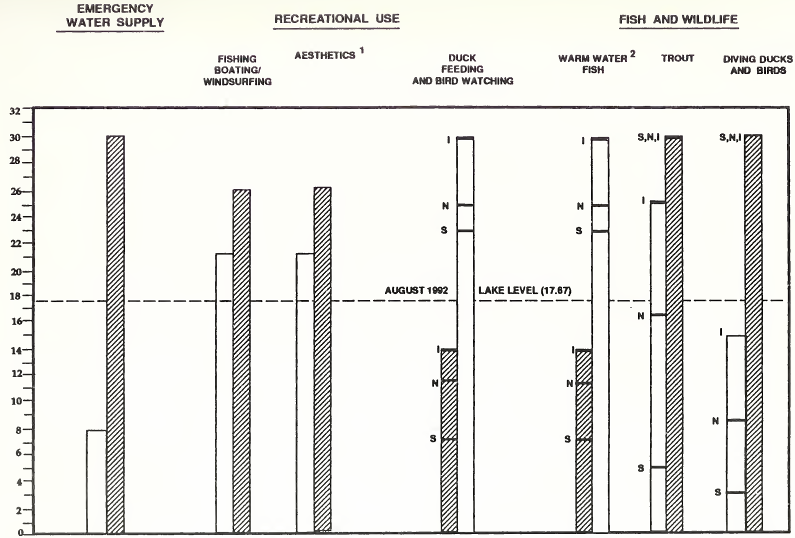
RELATION OF HABITAT VALUE AND BANK STEEPNESS TO WATER LEVEL IN IMPOUND LAKE
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
3-7



NOTE : N - NORTH LAKE, S = SOUTH LAKE, I = IMPOUND LAKE

1) ESTIMATE IS CONSISTENT WITH FISHING AND BOATING CRITERIA.
2) INCLUDES APPROXIMATE LEVELS FOR MARSH HABITAT, TURTLES, FROGS, AND DABBLING DUCKS. SEE FIGURE 3-5 THROUGH 3-7 FOR FURTHER DIFFERENTIATION.

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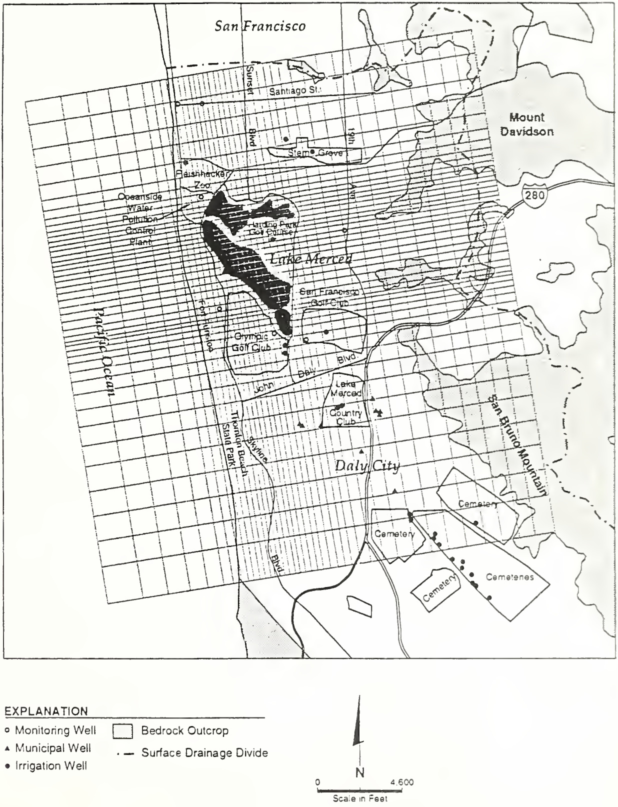
LAKE MERCED BENEFICIAL USE
LAKE LEVEL REQUIREMENTS
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
3-8



REFERENCE : Jones & Stokes Associates, Inc

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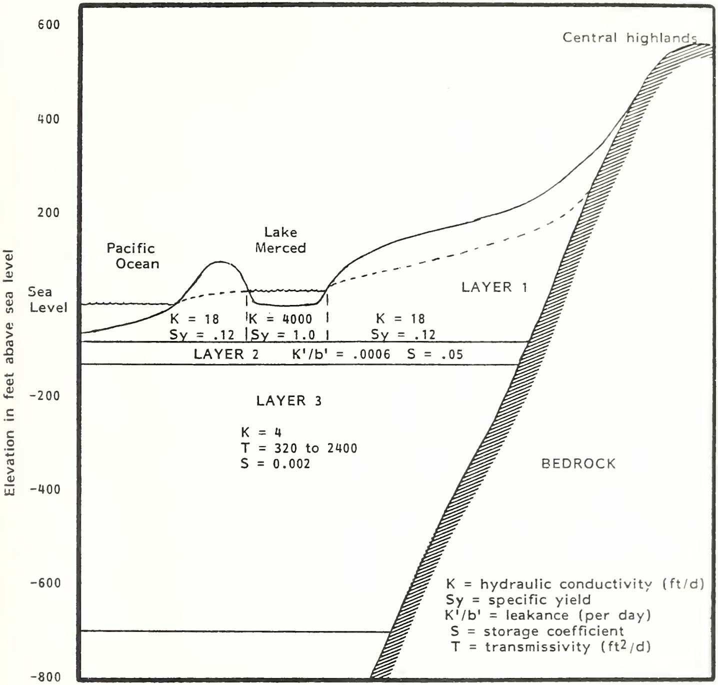
LOCATION OF LAKE MERCED, WELLS, CULTURAL FEATURES, AND MODEL GRID
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
6-1



REFERENCE : Jones & Stokes Associates, Inc.

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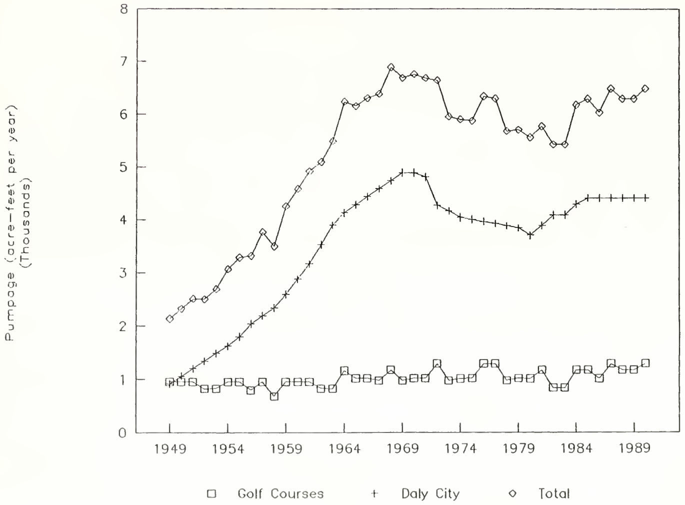
CROSS SECTION OF MODEL LAYERS
AND AQUIFER CHARACTERISTICS
LAKE MERCED WATER RESOURCE
PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
6-2

LAKE MERCED – DALY CITY AREA PUMPAGE



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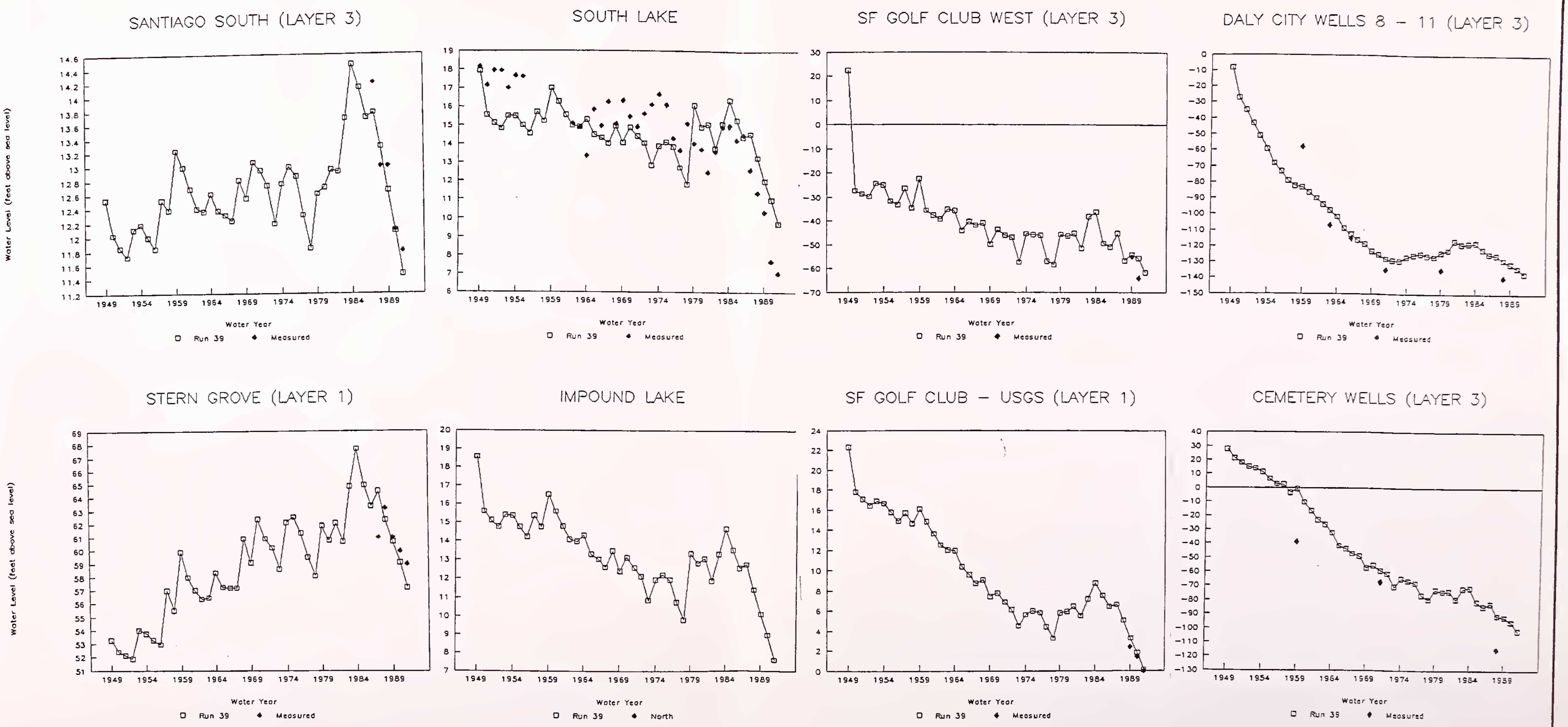
ESTIMATED ANNUAL MUNICIPAL, IRRIGATION, AND TOTAL PUMPAGE (1949-1990)
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE

6-3



REFERENCE : Jones & Stokes Associates, Inc.

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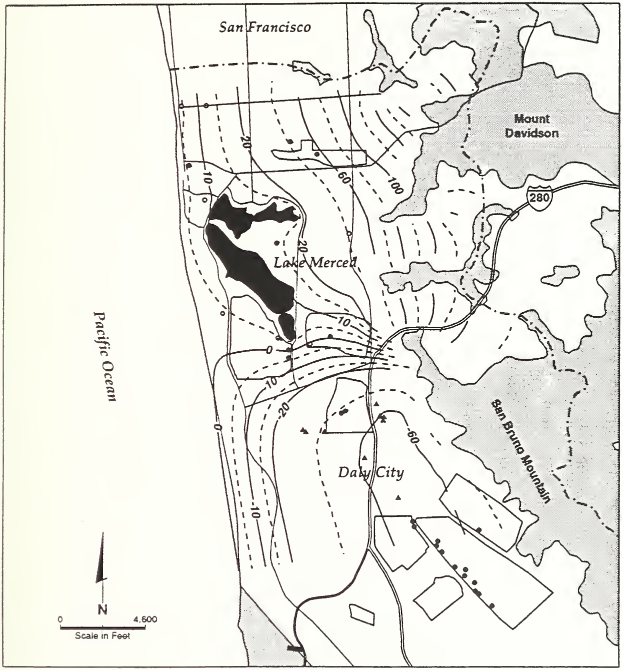
HYDROGRAPHS OF MEASURED AND
SIMULATED WATER LEVELS (1949-1990)
LAKE MERCED WATER RESOURCE
PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
6-4



EXPLANATION

- ○ Monitoring Well
- ▲ Municipal Well
- ● Irrigation Well
- ☐ Bedrock Outcrop
- · · — Surface Drainage Divide
- —— Contour of Simulated Water Levels in Feet Above Sea Level (contour interval varies)

REFERENCE : Jones & Stokes Associates, Inc.

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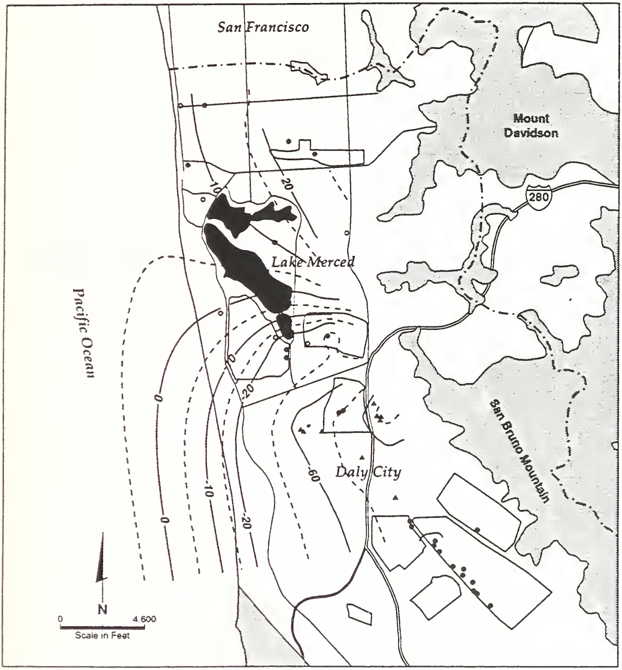
MEASURED WATER LEVELS AND CONTOURS OF SIMULATED WATER LEVELS IN THE SHALLOW AQUIFER (SEPTEMBER 1990)
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE 6-5



EXPLANATION

- ○ Monitoring Well
- ▲ Municipal Well
- ● Irrigation Well
- ☐ Bedrock Outcrop
- ‥ — Surface Drainage Divide
- —— Contour of Simulated Water Levels in Feet Above Sea Level (contour interval varies)

REFERENCE : Jones & Stokes Associates, Inc.

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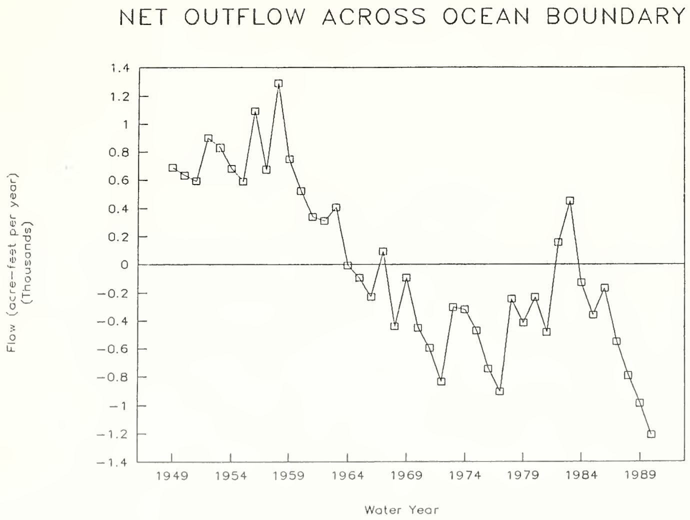
MEASURED WATER LEVELS AND CONTOURS OF SIMULATED WATER LEVELS IN THE DEEP AQUIFER (SEPTEMBER 1990)
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE 6-6



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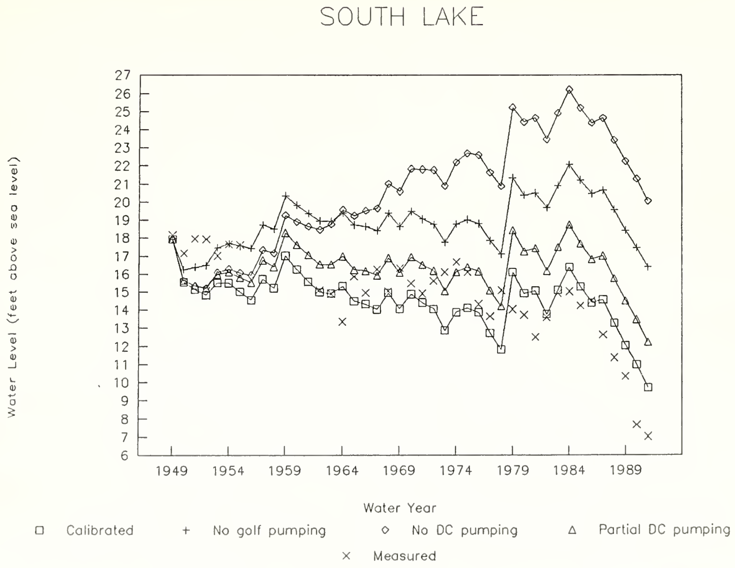
SIMULATED NET GROUNDWATER OUTFLOW
ACROSS THE OCEAN BOUNDARY (1949-1990)
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE

6-7



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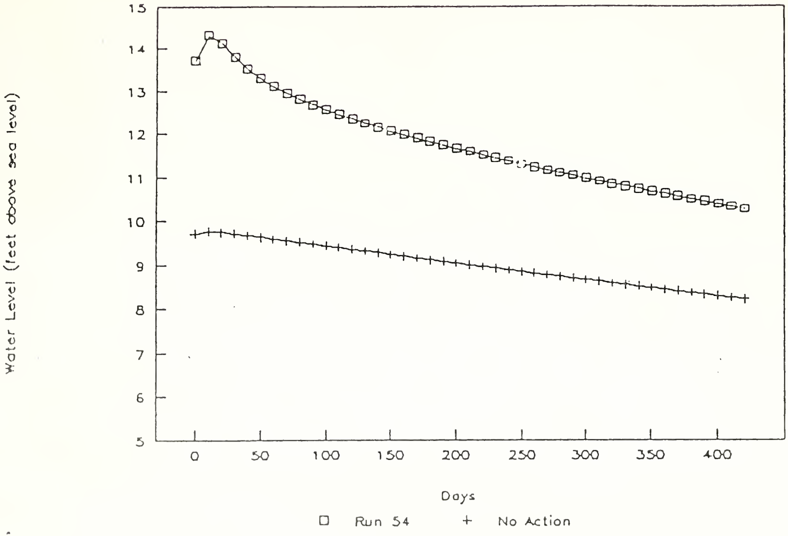
SIMULATED WATER LEVELS IN SOUTH LAKE
WITHOUT GOLF COURSE PUMPING, MUNICIPAL PUMPING,
OR PARTIAL MUNICIPAL PUMPING (1949-1990)
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE

6-8



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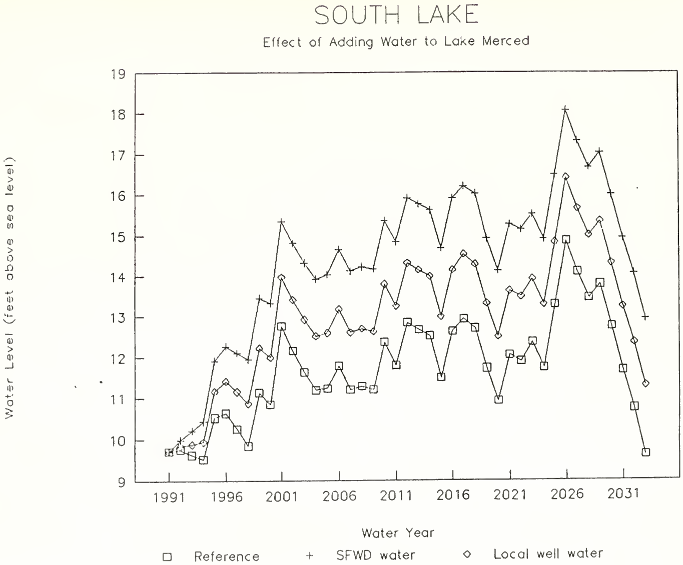
SIMULATED WATER LEVELS IN SOUTH LAKE
FOLLOWING A 4-FOOT INCREASE IN LAKE LEVEL
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
6-9



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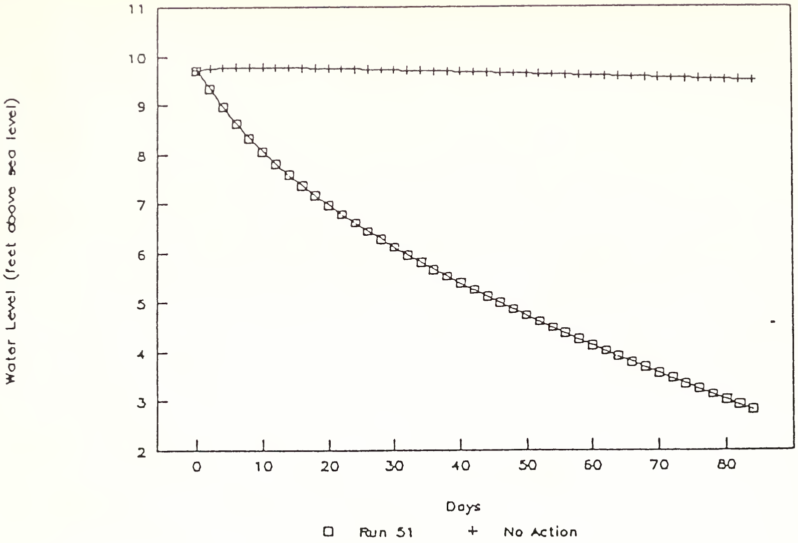
SIMULATED WATER LEVELS IN SOUTH LAKE
FROM ADDING 100 MGAL PER YEAR (1991-2032)
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
6-10



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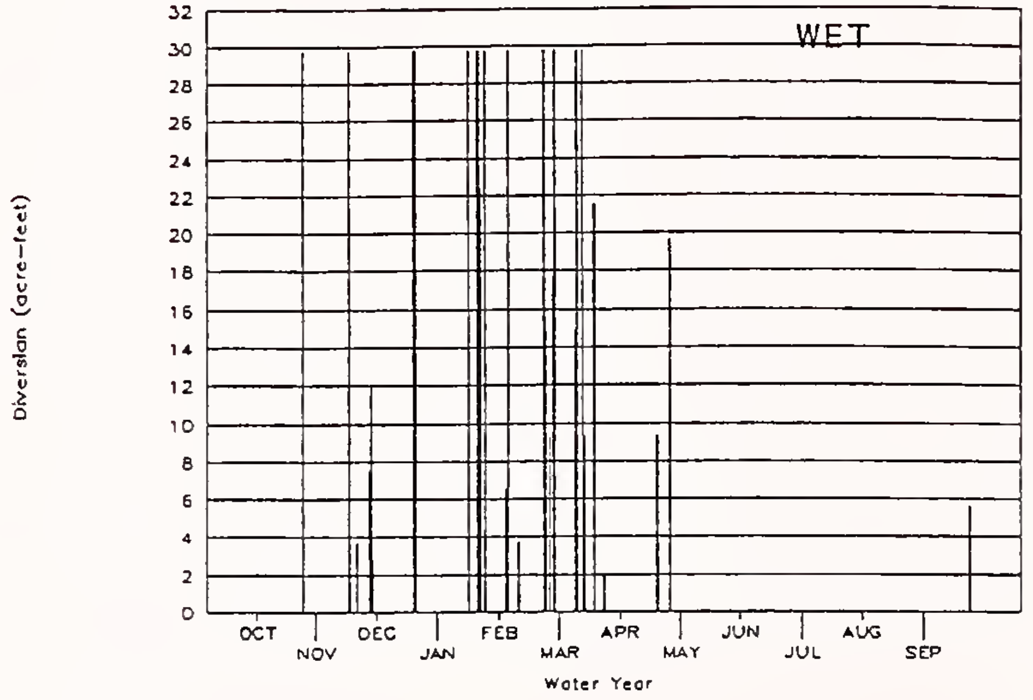
SIMULATED WATER LEVELS IN SOUTH LAKE PUMPING AT A RATE OF 50 MGD (FALL, 1990)
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE 6-11

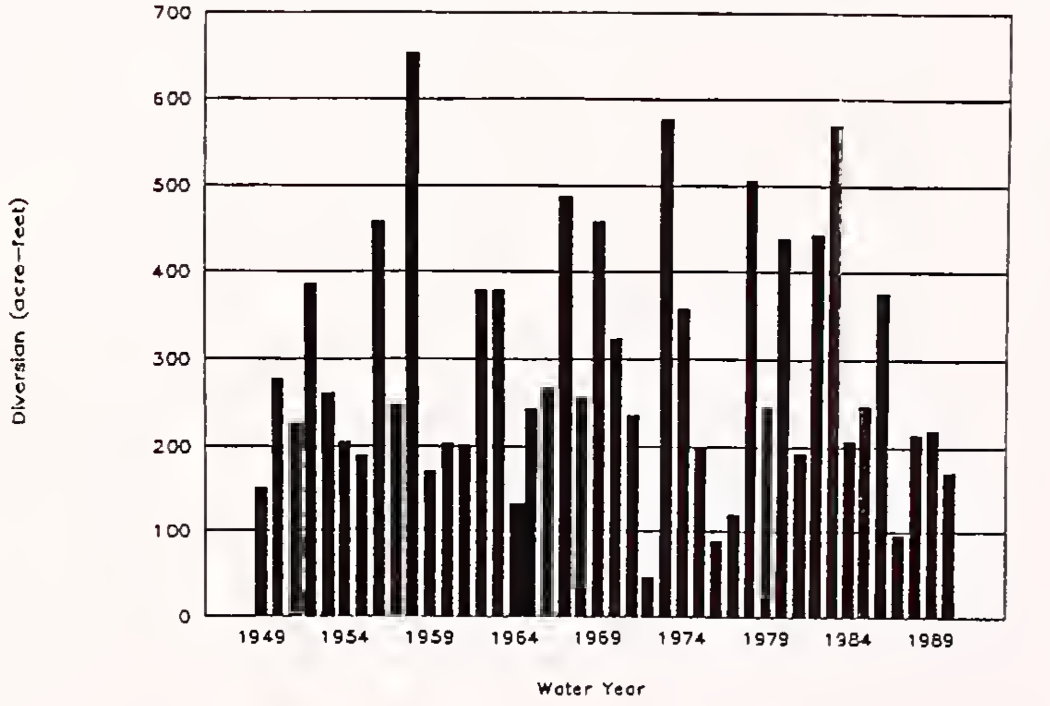
WY 1983 VISTA GRANDE TO LAKE MERCED

Bypass/MaxDiv=24/15 cfs, Total=570 af



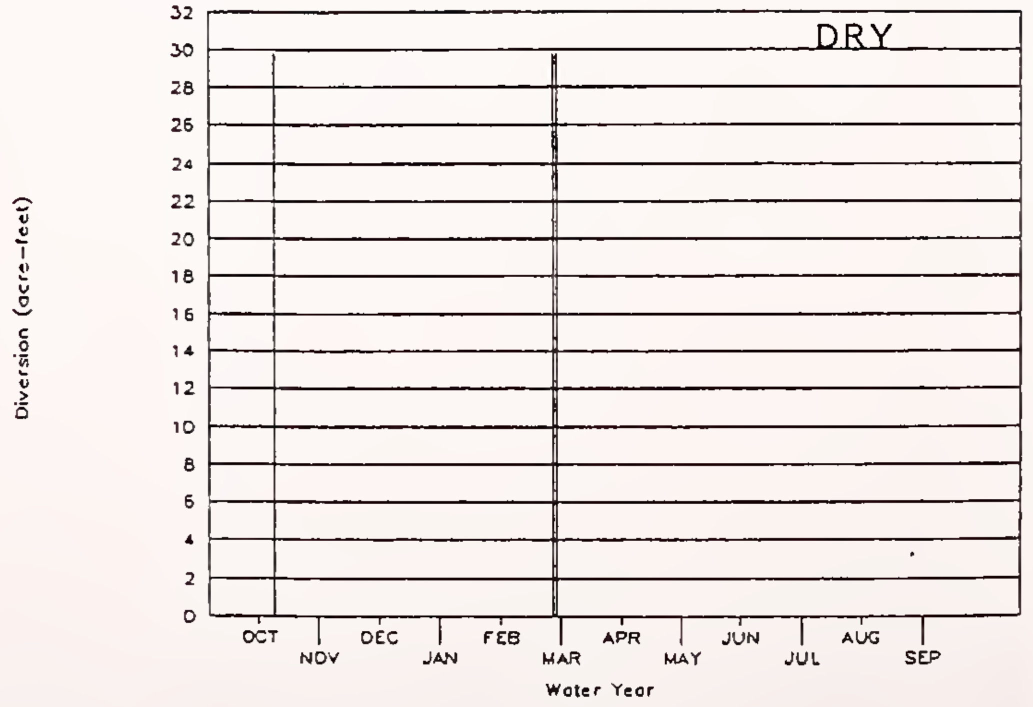
VISTA GRANDE DIVERSIONS TO LAKE MERCED

Bypass/MaxDiv=24/15 cfs, Avg.=288 af/yr



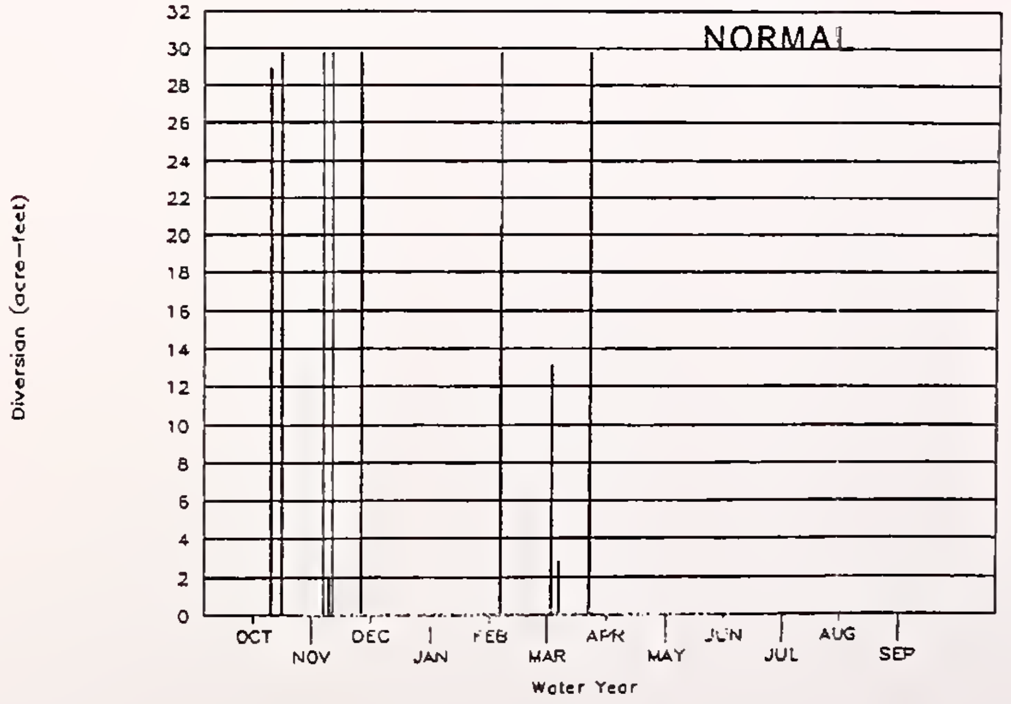
WY 1976 VISTA GRANDE TO LAKE MERCED

Bypass/MaxDiv=24/15 cfs, Total=89 af



WY 1985 VISTA GRANDE TO LAKE MERCED

Bypass/MaxDiv=24/15 cfs, Total=246 af



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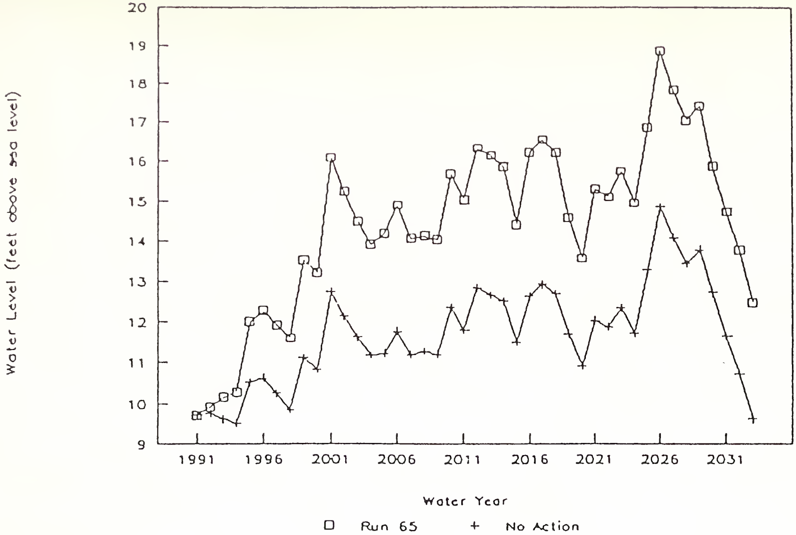
SIMULATED ANNUAL DIVERSIONS FROM VISTA GRANDE (1949-1990) AND DAILY DIVERSIONS IN NORMAL, WET, AND DRY YEARS
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
7-1



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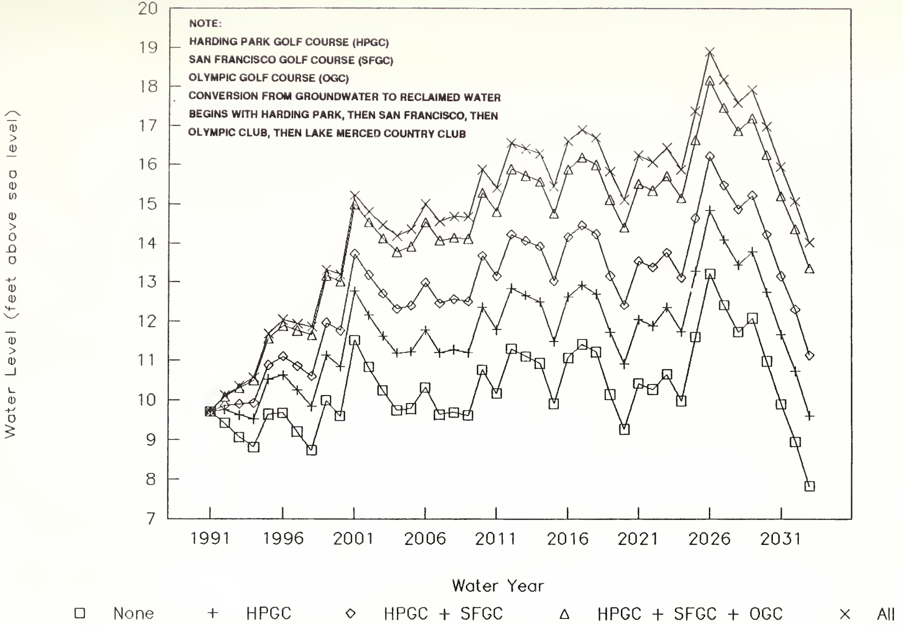
CONTOURS OF SIMULATED WATER LEVELS IN SOUTH LAKE
WITH DIVERSIONS FROM VISTA GRANDE STORMWATER RUNOFF (1991-2032)
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
7-2



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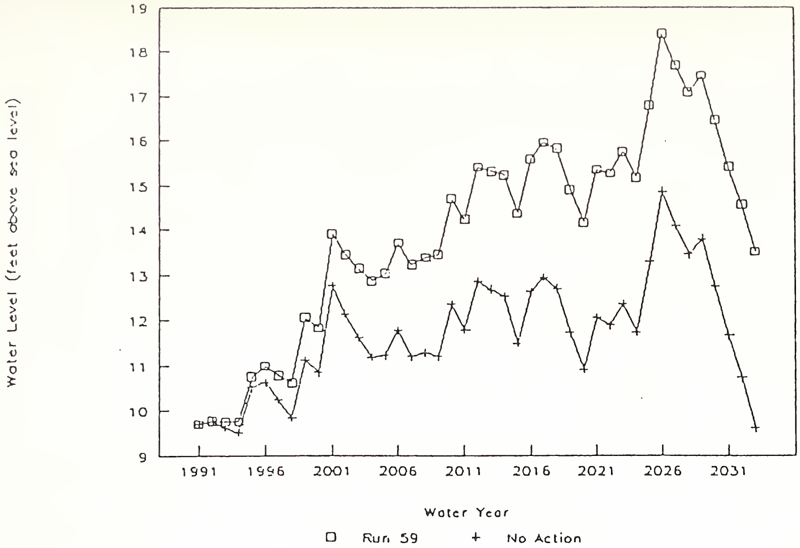
SIMULATED WATER LEVELS IN SOUTH LAKE
FROM CONVERTING GOLF COURSE IRRIGATION
TO RECLAIMED WATER (1991-2032)
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
7.3



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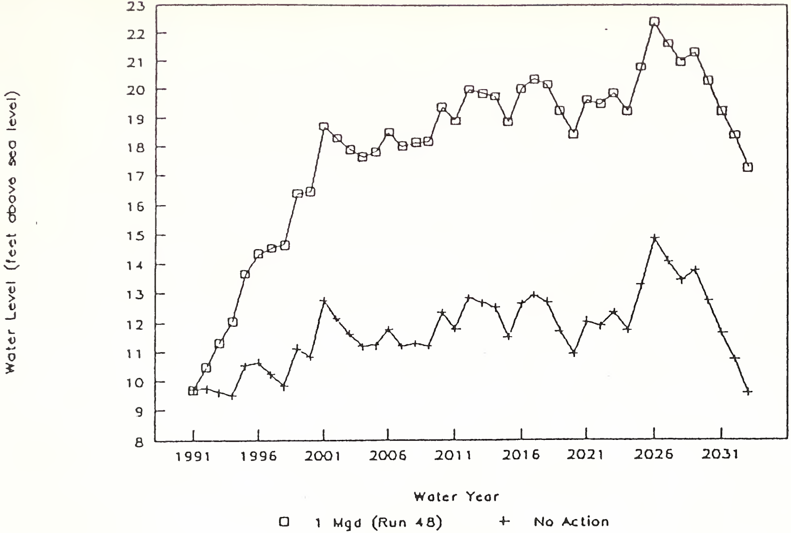
SIMULATED WATER LEVELS IN SOUTH LAKE
FROM DECREASING DALY CITY
MUNICIPAL PUMPAGE (1991-2032)
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
7-4



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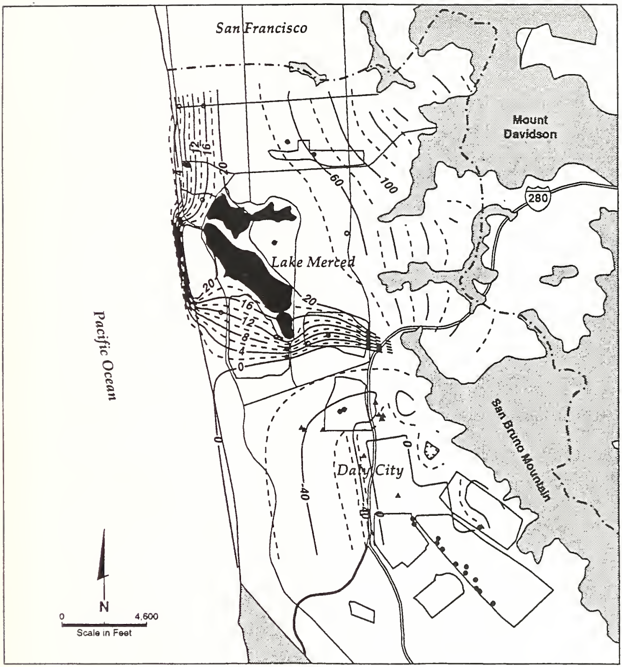
Job No. 1756-001 **Appr** ______ **Date** 2/23/93

SIMULATED WATER LEVELS IN SOUTH LAKE FROM RECHARGING SAND BARRIER WITH RECLAIMED WATER (1991-2032)
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
7-5



EXPLANATION

- ○ Monitoring Well
- ▲ Municipal Well
- ● Irrigation Well
- ▨ Bedrock Outcrop
- ·· — Surface Drainage Divide
- —— Contour of Simulated Water Levels in Feet Above Sea Level (contour interval varies)

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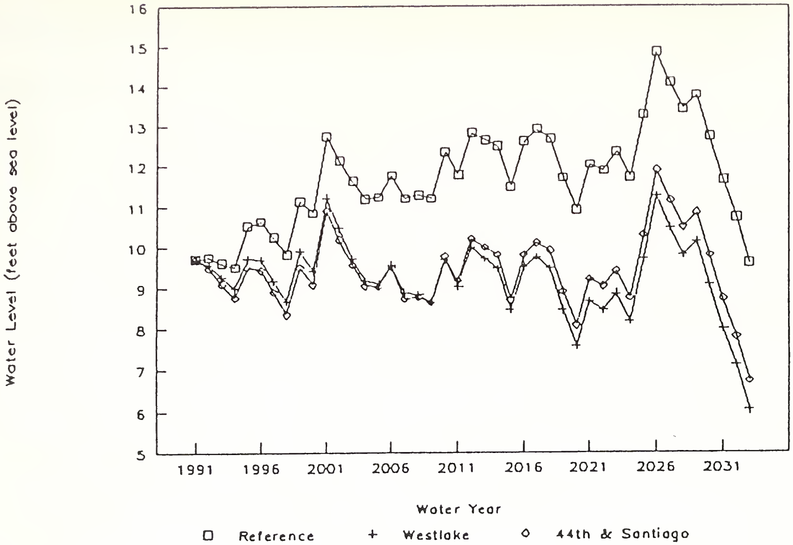
CONTOURS OF SIMULATED WATER LEVELS IN THE SHALLOW AQUIFER FROM RECHARGING RECLAIMED WATER ALONG THE SAND BARRIER (YEAR 2010)
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE 7-6



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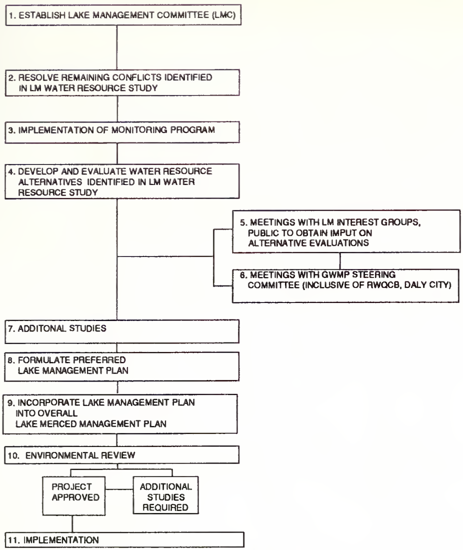
505 BEACH STREET, SAN FRANCISCO, CALIFORNIA 94133

Job No. 1756-001 **Appr** **Date** 2/23/93

SIMULATED WATER LEVELS IN SOUTH LAKE FROM NEW MUNICIPAL WELLS IN DALY CITY AND SAN FRANCISCO (1991-2032)
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
7-7



TASK	RESPONSIBILITY/INVOLVEMENT	PRODUCT
1. ESTABLISH LAKE MANAGEMENT COMMITTEE (LMC)	EXISTING STEERING COMMITTEE	COMMITTE FORMED TO INCLUDE : REC. & PARK, SFDPH, SFDPW, SFWD WATER QUALITY, SFWD OPERATONS SCHEDULE TO CONDUCT FOLLOWING TASKS
2. RESOLVE REMAINING CONFLICTS IDENTIFIED IN LM WATER RESOURCE STUDY	LMC/PUBLIC RELATION CONSULTANT	CONSENSUS REPORT DESCRIBING FINALIZED LM MANAGEMENT OBJECTIVES
3. IMPLEMENTATION OF MONITORING PROGRAM	SFWD WATER QUALITY /SFWD	QUARTERLY REPORTS
4. DEVELOP AND EVALUATE WATER RESOURCE ALTERNATIVES IDENTIFIED IN LM WATER RESOURCE STUDY	LMC/ENGINEERING CONSULTANT	TECHNICAL MEMORANDUM DESCRIBING AND RANKING ALTERNATIVES USING MATRIX APPROACH
5. MEETINGS WITH LM INTEREST GROUPS, PUBLIC TO OBTAIN IMPUT ON ALTERNATIVE EVALUATIONS	LMC/PR CONSULTANT	TECHNICAL MEMORANDUM DESCRIBING INPUT AND PROPOSED MODIFICATIONS TO RANKING
6. MEETINGS WITH GWMP STEERING COMMITTEE (INCLUSIVE OF RWQCB, DALY CITY)	LMC/ENGINEERING CONSULTANT	TECHNICAL MEMORANDUM DESCRIBING HOW ALTERNATIVES WILL FIT IN WITH PLANS FOR AQUIFER AS A WHOLE, PROPOSE MODIFICATIONS TO RANKING
7. ADDITONAL STUDIES		
8. FORMULATE PREFERRED LAKE MANAGEMENT PLAN	LMC/ENGINEERING CONSULTANT	REPORT DESCRIBING PREFERRED LAKE MANAGEMENT PLAN ITEMIZING : WATER DEVELOP/QUALITY CRITERIA
9. INCORPORATE LAKE MANAGEMENT PLAN INTO OVERALL LAKE MERCED MANAGEMENT PLAN	RECREATION PARK, SFDPW/ PLANNING CONSULTANT	OVERALL MANAGEMENT PLAN THAT WILL ENCOMPASS LAKE MANAGEMENT ISSUES AS WELL AS OTHER PARK MAINTENANCE AND OPERATIONS ISSUES
10. ENVIRONMENTAL REVIEW	PUC/ENGINEERING CONSULTANT	EIR OR NEGATIVE DECLARATION
11. IMPLEMENTATION	PUC/CONSULTANTS	PUC RESOLUTION LAKE MERCED WITH IMPROVED WATER LEVEL AND QUALITY

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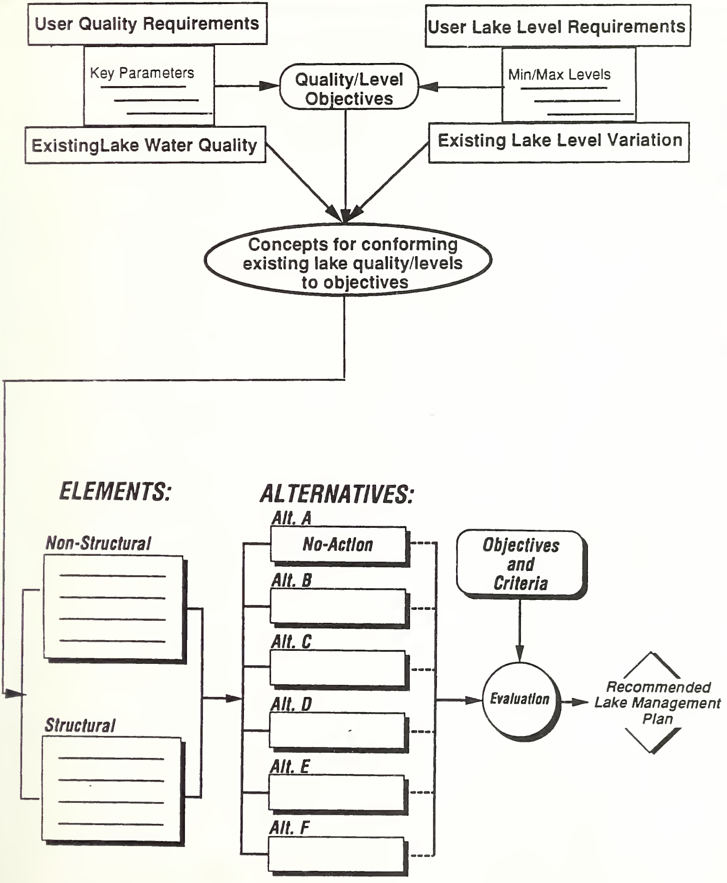
LAKE MANAGEMENT STRATEGY
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
8-1


User Quality Requirements
Key Parameters
Quality/Level Objectives
User Lake Level Requirements
Min/Max Levels
ExistingLake Water Quality
Existing Lake Level Variation
Concepts for conforming existing lake quality/levels to objectives
ELEMENTS:
Non-Structural
Structural
ALTERNATIVES:
Alt. A
No-Action
Alt. B
Alt. C
Alt. D
Alt. E
Alt. F
Objectives and Criteria
Evaluation
Recommended Lake Management Plan

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DEVELOPMENT AND EVALUATION OF PROJECT ALTERNATIVES
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
8-2

FIGURE 8-3
San Francisco Water Department
LAKE MERCED WATER MANAGEMENT PLAN

Preliminary Matrix for Evaluation of Lake Management Alternatives

		Rating/Ranking of Alternatives*							
Evaluation Criteria	Weighting Factor	A	B	C	D	E	F	G	H
Meeting Lake Management Objectives									
Water Quality									
Lake Level (Elevation 26, Staff Gage)									
Economic Considerations									
Capital (Construction) Cost									
Operation and Maintenance Cost									
Non-Economic Considerations									
Environmental Impact									
Short-term (Construction)									
Long-term									
Source Reliability									
Flexibility									
Implementability									
Regulatory Requirements (permits)									
Water Rights									
Rating of Alternatives (Total Points)									
Ranking of Alternatives									

NOTES:

* Alternatives are defined as follows:

- A - No Action
- B - Add Hetch Hetchy water
- C - Add well water from outside lake groundwater capture zone
- D - Add well water from within lakecapture zone
- E - Substitute reclaimed water for golf course pumping
- F - Add stormwater
- G - Recharge coastal groundwater with reclaimed water
- H - Reduce existing municipal pumping (Daly City) or potential future pumping (Daly City and San Francisco) **

** Not quantified within this study.

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PRELIMINARY MATRIX FOR EVALUATION OF LAKE MANAGEMENT ALTERNATIVES
LAKE MERCED WATER RESOURCE PLANNING STUDY
SAN FRANCISCO, CALIFORNIA

FIGURE
8-3

TABLES

TABLE 2-1
SOUTH LAKE WATER QUALITY ANALYSIS JAN. 1989 - DEC. 1992
Lake Merced Water Resource Planning Study

Date	pH	Alkalinity	Chloride	Hardness	Turbidity	Color	Conductivity	Total Coliform
1989								
January	8.4	206	87	233	6.6	25	690	105
February	8.4	203	87	226	7	/	681	82
March	8.6	201	84	230	7.3	25	679	54
April	8.6	200	85	223	10.8	30	680	72
May	8.9	214	87	232	12.5	>50	689	59
June	8.7	209	87	228	7.1	/	694	89
July	8.6	214	89	229	3.3	15	709	112
August	8.7	222	92	235	5.5	30	717	108
September	8.7	216	92	231	8.5	15	769	112
October	8.9	222	94	243	13	20	786	245
November	8.8	219	93	235	6.8	15	743	320
December	8.8	217	92	236	7.9	/	670	362
1990								
January	8.5	218	92	239	6.9	10	676	102
February	8.5	217	91	237	5.5	15	673	127
March	8.6	217	90	231	8.9	/	676	52
April	8.8	230	92	252	17	50	704	143
May	8.8	225	92	247	17	50	716	155
June	8.8	223	93	240	6	20	702	154
July	8.7	224	96	238	12.8	/	752	99
August	8.6	228	103	246	8.7	35	777	419
September	8.7	240	108	258	10.4	35	797	168
October	8.7	242	109	254	16.3	25	805	153
November	8.5	242	111	268	9	15	812	454
December	8.5	234	109	253	11.8	/	809	288
1991								
January	8.5	235	109	267	9.5	20	810	165
February	8.6	232	105	258	9.5	20	803	83
March	8.6	226	102	252	8	15	782	76
April	8.6	228	102	252	11.1	15	774	64
May	8.7	227	103	248	8.6	20	784	104
June	8.8	238	106	261	10.9	15	790	282
July	8.7	256	106	265	12	30	819	1630
August	8.8	218	110	262	17	25	809	215
September	8.8	245	110	259	10.5	15	817	154
October	8.7	250	107	269	11	/	922	1152
November	8.7	247	108	276	26.7	/	829	2672
December	8.5	244	133	265	52	30	814	243
1992								
January	8.6	239	111	258	27	45	815	81
February	8.6	233	108	256	15.4	30	800	671
March	8.6	229	105	243	42	/	771	139
April	8.7	227	102	240	21	30	770	190
May	8.7	238	139	212	14	/	786	124
June	8.6	245	111	251	14.1	/	776	248
July	8.7	248	107	257	19	/	819	752
August	8.6	248	112	257	16	/	832	341
September	8.7	254	115	268	12.1	/	836	330
October	8.7	251	115	264	11	/	841	/
November								
Average	8.7	229	102	247	13.2	26	765	305

TABLE 2-1 (continued)
NORTH LAKE WATER QUALITY ANALYSES JAN. 1989 - DEC. 1992
Lake Merced Water Resource Planning Study

Date	pH	Alkalinity	Chloride	Hardness	Turbidity	Color	Conductivity	Total Coliform
1989								
January	8.2	239	92	263	20	>50	770	55
February	8.5	234	92	266	14.9		754	30
March	8.7	231	87	260	8.5	30	747	36
April	9.2	234	89	257	18.9	35	733	83
May	9.2	224	88	244	36	>50	698	66
June	9.2	222	90	242	31	/	708	59
July	92	224	92	244	30	>50	720	33
August	9	232	95	250	19	>50	744	103
September	8.6	239	96	259	17	20	816	191
October	8.6	245	95	267	22	30	846	63
November	8.4	247	96	267	22	20	767	218
December	8.5	245	93	271	19	>50	734	938
1990								
January	8.2	240	93	268	17.7	15	741	70
February	8.3	230	92	266	11.5	30	737	72
March	8.4	235	90	265	11.9	/	735	35
April	8.8	233	92	268	14.2	50	707	65
May	8.8	225	92	248	23.5	35	704	132
June	9	232	94	256	23.1	40	734	313
July	8.6	242	95	261	15.7	/	797	313
August	8.5	252	99	274	11	30	821	104
September	8.9	260	100	286	24.3	50	820	212
October	8.6	260	101	278	23.8	35	828	39
November	8.6	264	101	282	24.8	10	842	115
December	8.5	265	100	287	24.3	/	846	47
1991								
January	8.6	234	99	288	20.8	50	842	47
February	8.7	255	97	284	26	30	831	390
March	8.6	250	95	279	23	30	812	113
April	8.6	245	60	275	21.9	25	802	228
May	8.7	251	94	279	22	26	806	30
June	8.7	255	95	289	12.4	25	822	603
July	8.6	255	100	277	14.6	35	838	220
August	8.6	265	100	293	17.6	30	849	36
September	8.5	267	102	291	12.2	20	868	730
October	8.4	270	100	303	9.1	/	874	475
November	8.6	244	102	286	17.7	/	856	1040
December	8.3	265	121	302	16	45	840	4425
1992								
January	8.4	259	101	292	17.2	45	847	1166
February	8.5	251	100	293	13	25	827	4244
March	8.7	249	95	277	18	/	803	499
April	8.8	241	92	264	26	40	786	525
May	8.8	241	139	211	14	/	788	453
June	8.7	255	93	268	17	/	788	169
July	8.8	258	101	271	28	/	822	511
August	8.9	262	99	272	31	/	823	1175
September	8.7	274	103	281	21	/	843	316
October	8.8	279	102	282	19	/	854	
November								

TABLE 2-2
FERTILIZER AND PESTICIDE APPLICATION ANNUAL USE AT HARDING GOLF COURSE
Lake Merced Water Resource Planning Study

PESTICIDES		ANNUAL ESTIMATED USE
FFII	Fungicide w/ Fertilizer	500 LBS.
Bayleton 25%	Fungicide	22 LBS.
Clearys 3336	Fungicide	12 LBS.
Chipco 26019	Fungicide	ZERO
Subdue 2E	Fungicide	ZERO
Mancoze B	Fungicide	10 GALLONS
Round-up	Herbicide	2 GALLONS
Banvel	Herbicide	7 GALLONS
Trimel	Herbicide	29 GALLONS
Turflow Estel	Herbicide	1 GALLON
Eatons Answer	4 oz. Gopher Blocks	37 LBS.
FERTILIZERS		
Calcium Nitrate	15-0-0	1100 LBS.
Scotts	15-0-30	400 LBS.
Mini Pellet (BEST)	16-4-8	1400 LBS.
Malorganite (ORGANIC)		6000 LBS.
Par Ex	21-0-0	5000 LBS.
Ammonium Sulfate	21-0-0	700 LBS.
H. Potassium	15-0-30	1000 LBS.

TABLE 3-1
FISH OCCURRING IN LAKE MERCED
Lake Merced Water Resource Planning Study

COMMOM NAME	SCIENTIIFIC NAME
Carp	Cyrinus carpio
Channel catfish	Ictalurus punctatus
Larfemouth bass	Micrpoterus salmoides
Rainbow trout	Oncorhynchus mykiss
Redear sunfish	Lepomis microlophus
Threespine sticklet	Gasterosteus aculeatus
Tule perch	Hysterocarous traski
SOURCE: Senti pers. comm.	

TABLE 3-2
SUMMARY OF MANAGEMENT STRATEGIES AND POTENTIAL CONFLICTS
Lake Merced Water Resource Planning Study

Beneficial Uses	Specific Uses	Water Quality Standards	Current Status of Lake Merced with regard to applicable standards	Preferable Management Strategy	Conflicts
Emergency Water Supply[1]	First Choice	Does not exceed primary standard. Exceeds secondary (aesthetic) drinking water standards.	Lake Merced currently exceed: Primary Standards Coliform, up to 4,425 MPN/100ml (Dec. 1991) - Federal MCL - Absent Turbidity, up to 26.7 NTU (Nov. 1991) - State MCL-0.5 NTU Secondary Standards Manganese, up to 0.114 mg/l color, >50 units MBAS, not tested but could exceed Odor, not tested but could exceed	- Maintain lake level between 9 and 30 feet (lower level required for proper operation of pumps, however higher level desired). - Improve water quality: Disinfect to reduce coliform. Reduce turbidity odor and color levels through copper sulfate treatment or aeration just prior to distribution. Provide additional restrooms around the lake to help reduce coliform levels.	- High lake level may conflict with optimum management strategy for tule and marsh habitat, warm water fish, bird watching - Algae treatment conflicts with fish maintenance.
	Second Choice	Exceeds primary (health related) drinking water standards that only pose long term or chronic threats to health. Examples include above maximum contaminant level (MCL), but less than five times MCL of trichloroethylene (TCE), petrachloroethylene (PCE), etc.	Based on current water quality information Lake Merced would probably be a second choice emergency water supply.	- Maintain lake level between 9 and 30 feet (lower level required for proper operation of pumps, however higher level desired). - Improve water quality: Disinfect to reduce coliform. Reduce turbidity odor and color levels through copper sulfate treatment or aeration just prior to distribution. Provide additional restrooms around the lake to help reduce coliform levels.	Minimal conflicts with other uses. - High lake level may conflict with optimum management strategy for tule and marsh habitat, warm water fish, bird watching. - Algae treatment conflicts with fish maintenance.
	Third and Fourth Choice	Exceeds primary drinking water standards that poses short to long term or chronic health threats with greater than five times MCL to ten times MCL.	Lake Merced is probably above third choice emergency water supply.	- To maintain as a third or fourth choice emergency water supply water quality could be allowed to drop to lower levels.	Minimal conflicts with other uses. - High lake level may conflict with optimum management strategy for tule and marsh habitat, warm water fish, bird watching.
Fish and Wildlife Habitat[2]	Tule and Marsh Habitat	RWQCB water quality objectives apply. Special status species protection under CEQA.	Generally conforms with the RWQCB and CEQA objectives.	- See Figures 3-5 through 3-7 for lake levels to maintain fair conditions.	Low lake level may conflict with management strategy for all other uses except warm water fish, bird watching.

TABLE 3-2 (continued)
SUMMARY OF MANAGEMENT STRATEGIES AND POTENTIAL CONFLICTS
Lake Merced Water Resource Planning Study

Beneficial Uses	Specific Uses	Water Quality Standards	Current Status of Lake Merced with regard to applicable standards	Preferable Management Strategy	Conflicts
Fish and Wildlife Habitat (continue)	Diving Ducks, Birds and Dabbling Ducks	RWQCB water quality objectives apply. Special status protection under CEQA.	Generally conforms with the RWQCB and CEQA objectives except: - Lead concentrations in sediment samples are high (14,000 parts per million) near the Pacific Rod and Gun Club would be deleterious to waterfowl if ingested.	- See Figures 3-5 through 3-7 for lake levels to maintain fair conditions. - Monitor lead in waterfowl and reduce lead in sediments if necessary.	- High lake level may conflict with optimum management strategy for tule and marsh habitat, warm water fish, bird watching. - Management strategy to reduce lead contamination may conflict with use of the gun club or result in costs to implement a regular monitoring and/or dredging program.
	Turtles and Frogs	RWQCB water quality objectives apply. Special status species protection under CEQA.	Generally conforms with RWQCB and CEQA objectives.	- See Figures 3-5 through 3-7 for lake levels to maintain fair conditions.	- Low lake level may conflict with management for all other uses except warm water fish, bird watching.
	Warm Water Fish	RWQCB water quality objectives apply. Specific Objectives: - Dissolved oxygen concentration shall not be less than 5.0 ug/l.	Generally conforms with the RWQCB water quality objectives, except: - Low lake levels are reported to result in a slight increase in temperature however, temperature of either the lake or surrounding groundwater is not measured. - Dissolved oxygen content has been measured at 4.8 ug/l (See Section 3.3.3).	- See Figures 3-5 through 3-7 for lake levels to maintain fair conditions. - Maintain proper temperature and dissolved oxygen levels for cold water fish by raising lake level.	- Low lake level may conflict with optimum management for all other uses except warm water fish, bird watching.
	Trout	RWQCB water quality objectives apply. Specific objectives: - Dissolved oxygen concentration shall not be less than 7.0 ug/l.	Generally conforms with the RWQCB water quality objectives, except: - Low lake levels are reported to result in a slight increase in temperature, however, temperature of either the lake or surrounding groundwater is not measured. - Dissolved oxygen measured below 7.0 ug/l. (See Appendix C and Section 3.3.3).	- See Figures 3-5 through 3-7 for lake levels to maintain fair conditions. - Maintain proper temperature and dissolved oxygen levels for cold water fish by raising lake level.	- High lake level may conflict with optimum management strategy for the tule and marsh habitat, warm water fish, bird watching.

TABLE 3-2 (continued)
SUMMARY OF MANAGEMENT STRATEGIES AND POTENTIAL CONFLICTS
LAKE MERCED WATER RESOURCE PLANNING STUDY

Beneficial Uses	Specific Uses	Water Quality Standards	Current Status of Lake Merced with regard to applicable standards	Preferable Management Strategy	Conflicts
Recreation Uses[2]	Fishing	RWQCB water quality objectives for non-contact recreation apply. Specific Objectives: - All specific objectives listed above for Warm Water Fishes and Trout. - Water shall not contain taste or odor-producing substances that impact undesirable tastes or odors to fish flesh or other edible products of aquatic origin, that cause nuisance, or that adversely affect beneficial uses. - Fecal coliform - mean <2000 mpn	RWQCB water quality objectives not met: - Color, taste and odor, floating material, sediment, turbidity, dissolved oxygen. - Low lake levels have resulted in a slight increase in temperature. - Algae blooms have resulted in smelly water and musty tasting fish. - Fecal coliform not currently measured.	- Raise lake level to between 21 to 26 feet to meet water quality objectives and maintain fishing facilities. - Provide additional restrooms around the lake to help reduce coliform levels.	- High lake level may conflict with optimum management strategy for tule and marsh habitat, warm water fish, bird watching.
	Aesthetics (Walking, running, biking, picnicking, golfing, bird watching)	RWQCB water quality objectives for non-contact recreation apply.	RWQCB water quality objectives not met: - Color, odor, floating material, sediment, turbidity. - Fecal coliform not currently measured.	- Raise lake level to between 21 and 26 feet to meet water quality objectives and maintain boating facilities. - Provide additional restrooms around the lake to help reduce coliform levels.	- High lake level may conflict with optimum management strategy for tule and marsh habitat, warm water fish, bird watching.
	Boating	RWQCB water quality objectives for non-contact recreation apply. - Fecal coliform - mean <2000 MPN/100ml	RWQCB water quality objectives not met: - Color, odor, floating material, sediment turbidity. - Fecal coliform not currently measured.	- Raise lake level to between 21 and 26 feet to meet water quality objectives. - Provide additional restrooms around the lake to help reduce coliform levels.	- High lake level may conflict with optimum management strategy for tule and marsh habitat, warm water fish, bird watching.
	Windsurfing	RWQCB water quality objectives for water-contact recreation apply. Specific objectives: - Total coliform: For Water Contact Recreation - median <240 MPN/100; no sample >10,000 MPN/100 ml.	RWQCB water quality objectives not met: - Color, taste and odor, floating material, sediment, turbidity	- Raise lake level to between 21 and 26 feet to meet water quality objectives.	- Low lake level may conflict with optimum management strategy for all other uses except warm water fish and tule/marsh habitat.

1. Water Quality Standards based on State Department of Health Services DRP standards.
2. For Fish and Wildlife Habitat and Recreation beneficial uses, all State Regional Water Quality Control Board (RWQCB) "Objectives for Inland Surface Waters" apply (see Appendix H).

TABLE 4-1

RECOMMENDED WATER QUALITY MONITORING PROGRAM FOR LAKE MERCED BENEFICIAL USES

LAKE MERCED WATER RESOURCE PLANNING STUDY

QUALITY PARAMETER	EMERGENCY MUNICIPAL SUPPLY	RECREATION (NON-CONTACT)	RECREATION (WATER-CONTACT)	FISH AND WILDLIFE
pH*	X	X	X	X
Temperature		X	X	X
Turbidity*	X	X	X	X
Dissolved Oxygen*				X
Bacteria				
Fecal*	X	X	X	
Total*	X		X	
Algae (Chlorophyll-A)	X	X	X	X
Color*	X	X	X	
Taste/Odor	X	X	X	X
Conductivity*				X
Total Dissolved Solids*				X
Suspended Sediments		X	X	
Alkalinity*				X
Nitrogen*	X	X	X	X
Phosphorous*	X	X	X	X
Metals*	X			X
Pesticides/Herbicides	X			X
Total Organic Carbon	X			
Oil & Grease		X	X	

* Parameters currently monitored either monthly or annually by SFWD.

TABLE 6-1
SIMULATED GROUNDWATER BUDGETS IN WET, NORMAL, AND DRY YEARS AT EXISTING LEVELS OF PUMPAGE AND URBAN DEVELOPMENT
Lake Merced Water Resource Planning Study

WATER BUDGET ITEM	FLOW (ACRE-FEET PER YEAR)			
	1983 (WET)	1985 (NORMAL)	1990 (DRY)	1971-90 (AVERAGE)
Inflows				
Areal Recharge	8,319	4,300	2,730	5,075
Bedrock Inflow	433	433	433	433
Storage Decrease	6	1,730	2,606	1,151
TOTAL	8,758	6,463	5,870	6,658
Outflows				
Wells	5,628	6,569	6,786	6,200
Net Lake Evaporation	0	261	425	232
Net Flow to Ocean	452	-361	-1,213	-457
Storage Increase	2,569	102	0	806
TOTAL	8,649	6,572	5,999	6,780
Inflows-Outflows	109	-109	-129	-122

TABLE 7-1
SUMMARY OF EFFECTS OF WATER RESOURCE ALTERNATIVES ON WATER LEVELS IN LAKE MERCED
Lake Merced Water Resource Planning Study

ALTERNATIVE	WATER LEVEL CHANGE (Ft.)	LONG-TERM AVERAGE WATER LEVEL (Ft. above sea level)
No Action	0	12
Add imported water to lake (170 Mgal per year)	+5	17
Add deep well water to lake (250 Mgal per year)	+5	17
Add Vista Grande stormwater to lake (average rate if 133 Mgl per year)	+5	17
Irrigate golf course with reclaimed or municipal water:		
Harding Park (82 Mgla per year)	+0.6	16
SF Golf Club (89 Mgal per year)	+1.8	
Olympic Club (122 Mgal per year)	+1.8	
Lk. Merced CC (67 Mgal per year)	+0.6	
Replace 365 Mgal per year of Daly City pumpage with imported water	+3.5	15.5
Decrease outflow to ocean with reclaimed water recharge mound (146 Mgal per year)	+7	19
Add two new Daly City municipal wells (total of 365 Mgal per year)	-3.5	8.5
Add new SFWD municipal well at 44th and Santiago (365 Mgal per year)	-3	9

NOTE: Ware level changes are long-term changes with respect to the no-action alternative, which assume Harding Park Golf Course will continue to be irrigated with imported or reclaimed water. Irrigating Harding Park Golf Course with groundwater would decrease lake level 1.5 ft. relative to the no-action alternative.

TABLE 7-2
COMPARISON OF SUPPLEMENTAL SOURCE WATER QUALITY
Lake Merced Water Resource Planning Study

Water Quality Parameter	Units	MCL's	Existing Lake Merced Quality [1]	Supplemental Water Source			
				Groundwater [2]	Hetch Hetchy [3]	Stormwater [4]	Reclaimed Wastewater [5]
pH	Unit	-	8.7	7.7	8.5	7	--
Dissolved Oxygen	mg/l	-	6.5 [6]	--	--	7.8	--
Algae	Unit	--	--	--	--	--	--
Temperature	oO	--	14.5 [4]	15.8	12.7	15.5	--
Conductivity	us/cm	900(S)	765	599	43.3	56	1200
Turbidity	NTU	0.5 (P)	13.2	--	11	22.5	--
Alkalinity	mg/l	--	229	165	11	--	--
Chlorides	mg/l	250 (S)	102	49	2.6	5.2	194
Hardness	mg/l	--	247	--	--	38	--
Nitrogen (total as N)	mg/l	10 (P)	0.1 [2]	9.4	0.05	--	27.6
Phosphate	mg/l	--	0.031	--	--		--
Bacteria (Total Coliform)	MPN/ 100ml	Absent (P)	305	--	--	220,000	--
Color	Unit	15 (S)	26	--	11	--	--
Oil and Grease	mg/l	-	1.3 [4]	--	--	3.0	--
Total Suspended Solids	mg/l	-	13 [4]	--	--	44.5	--
Total Dissolved Solids	mg/l	500 (S)	472	--	--	41.5	663
Copper	mg/l	1.3 (AL)	0.002	--	11	0.02	0.053
Sodium	mg/l	-	76	59.3	1.8	4.2	128
Zinc	mg/l	5(S)	0.001	--	--	0.15	0.1338
Lead	mg/l	0.05 (AL)	0.003	--	--	0.046 (Feb.'93)	

SOURCE OF DATA

[1] **Lake Merced:** San Francisco Water Department monthly monitoring of South Lake; average for years 1989-92 (See Table 2-1) and annual monitoring for years 1989-1991 (See Appendix C).

[2] **Groundwater:** Sampling for the 1990 USGS Water-Resources Investigation 90-4080 "Geohydrology, Water Quality, and Water Budgets of Golden Gate Park and the Lake Merced Area in the Western Part of San Francisco, California"; the average for samples taken 11/17/87, 3/1/88, and 5/2/88 from wells: SF State, Olympic Club, SF Golf Club, Zoo, Stern Grove.

[3] **Hetch Hetchy:** Sampling of the Sunset Pipeline at the Lake Merced Pumping Station for the 1990 USGS Water-Resources Investigation 90-4080; the average for samples taken 11/17/87, 3/1/88, and 5/2/88.

[4] **Stormwater:** Sampling of Vista Grande Canal at Lake Merced Boulevard by Kennedy/Jenks Engineers; average of samples obtained on 2/13/84 and 3/13/84; sampling conducted in January and February, 1993 (See Appendix E).

[5] **Reclaimed Wastewater:** Sampling of Richmond-Sunset Wastewater Treatment Plant affluent conducted for the 1992 "San Francisco Draft Recycling Master Plan" by James M. Montgomery Consulting Engineers, Inc.; Average for samples obtained during 2/20-28/91 and 5/29-6/5/91. (From Table 5-1).

[6] **Measurements:** made by JSA September 1992, indicate D.O. at 7-8 mg/l at the top 3 feet and 4.8-5.8 mg/l to 12 feet.

See Appendix C for explanation of MCL's; P = Primary, S = Secondary, AL = Action Level 4

PHOTOGRAPHS

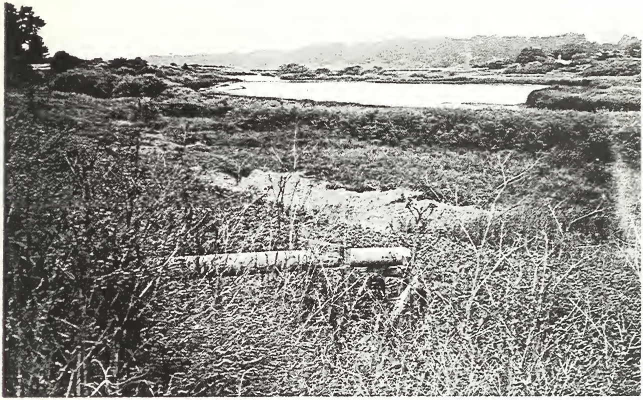

Photo 1: Stormwater drainage at Impound Lake.

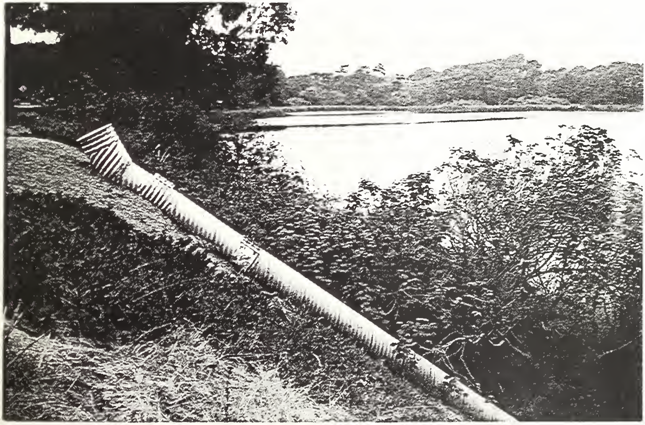

Photo 2: Stormwater drainage at North Lake.

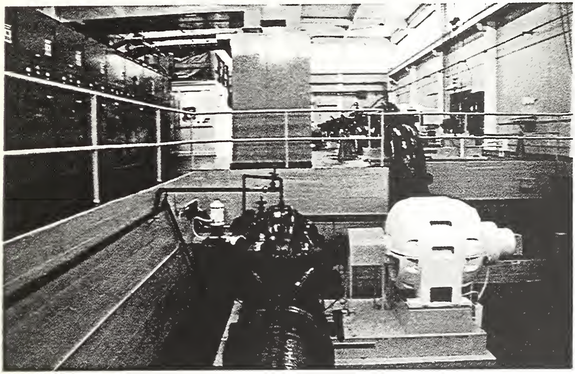

Photo 3: Lake Merced Pump Station.

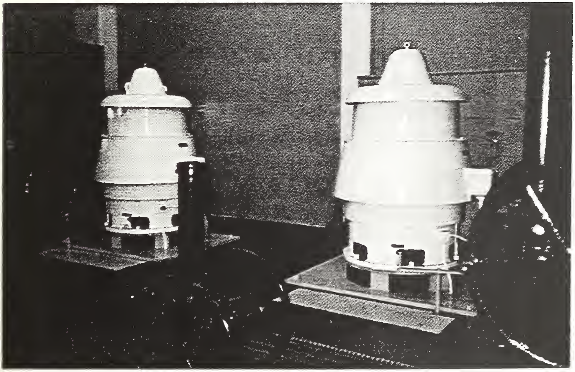

Photo 4: Pump No. 7 and No. 8.

State of California
Department of Health Services

PUMP STATION DATA

System Name: **LAKE MERCED** System No.
Source of Information: Murray/Gramberg
Collected by: Fong

Station Name: **Lake Merced Pump Station**
Date constructed: 1953
Location: Lake Merced Blvd near Brotherhood Way

Housing (Concrete structure)
Insulation: no
Heating: yes
Pit Depth: no
Drainage: to street

Relation to System
Receives from: 60" Sunset Supply Line/ Lake Merced
Delivers to: Sunset & Sutro Reservoirs/ Distribution system
Inlet pressure: 80 psi
Outlet pressure: 222 psi
Maximum capacity: 51 MGD
Flood Hazard: no

PUMPING UNITS	# 1, 2, & 3	# 4	# 5 & 6	# 7 & 8
Make	Byron Jackson	Byron Jackson	Byron Jackson	Fairbanks Morse
Type	CSS	CSS	CSS	CSS
Capacity (gpm)	11,500 @ 260' TDH	11,500 @ 154' TDH	17,250 @ 140' TDH	17,500
Lubrication	Oil & water	Oil & water	Oil & water	Oil
Power	1000 HP Electric	500 HP Electric	700 HP Electric	200 HP Electric
Auxiliary Power	yes	yes	yes	yes
Control	Manual (see tables below)			
Frequency of use	Operated per LMPS Chief or Senior Engineers			

Sunset Reservoir (6"High level 3'0" Low level)	
PUMP	ON
1	1'0"
2	2'0"
3	3'0"

Sutro Reservoir (6"High level 3'0" Low level)	
PUMP	ON
4	3'0"
5	4'0"
6	5'0"

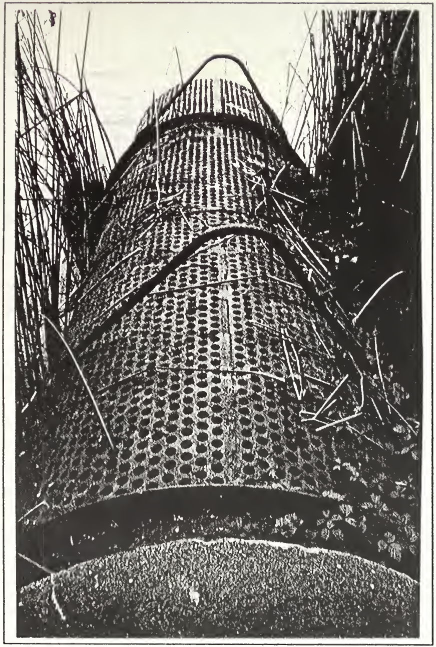

Photo 5: Upper intake drum (close-up).

Photo 6: Upper intake drum.

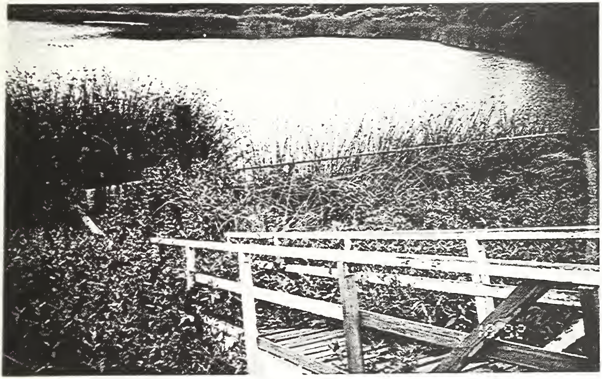

Photo 7: Children's fishing pier - South Lake (closed).

Photo 8: Shore area exposed by low water level - South Lake.

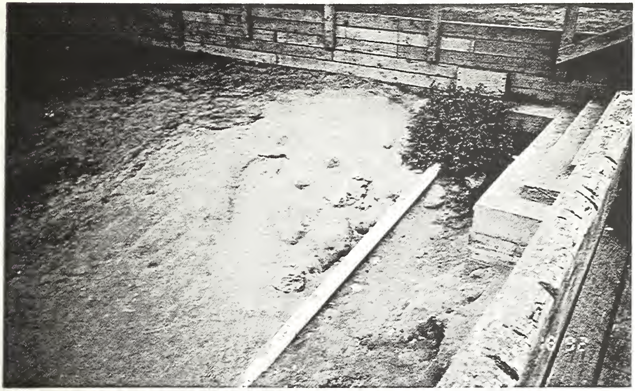

Photo 9: Erosion resulting from low water level - South Lake.

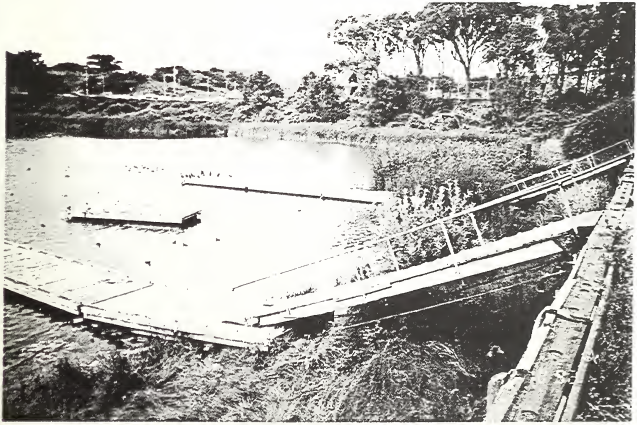

Photo 10: Steep access to boating piers - South Lake.

Photo 11: Steep access ramp - South Lake.

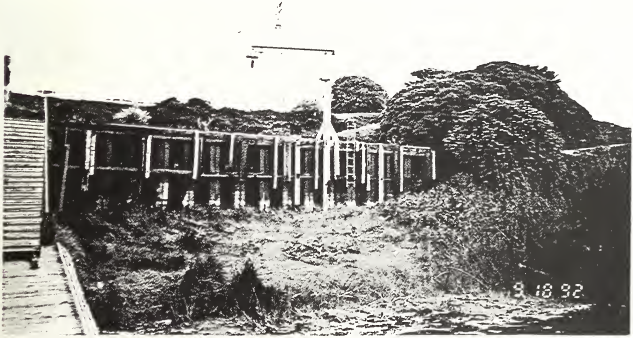

Photo 12: Boat hoist (South Lake) closed due to low water level.

Photo 13: Boat launch area - North Lake.

Photo 14: Tule and willow encroachment onto mud flats at Impound Lake.